ENGINEERING

An Illustrated Weekly Journal

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VOL. 177 No. 4597 LONDON, FRIDAY, MARCH 19, 1954 Price 2s.

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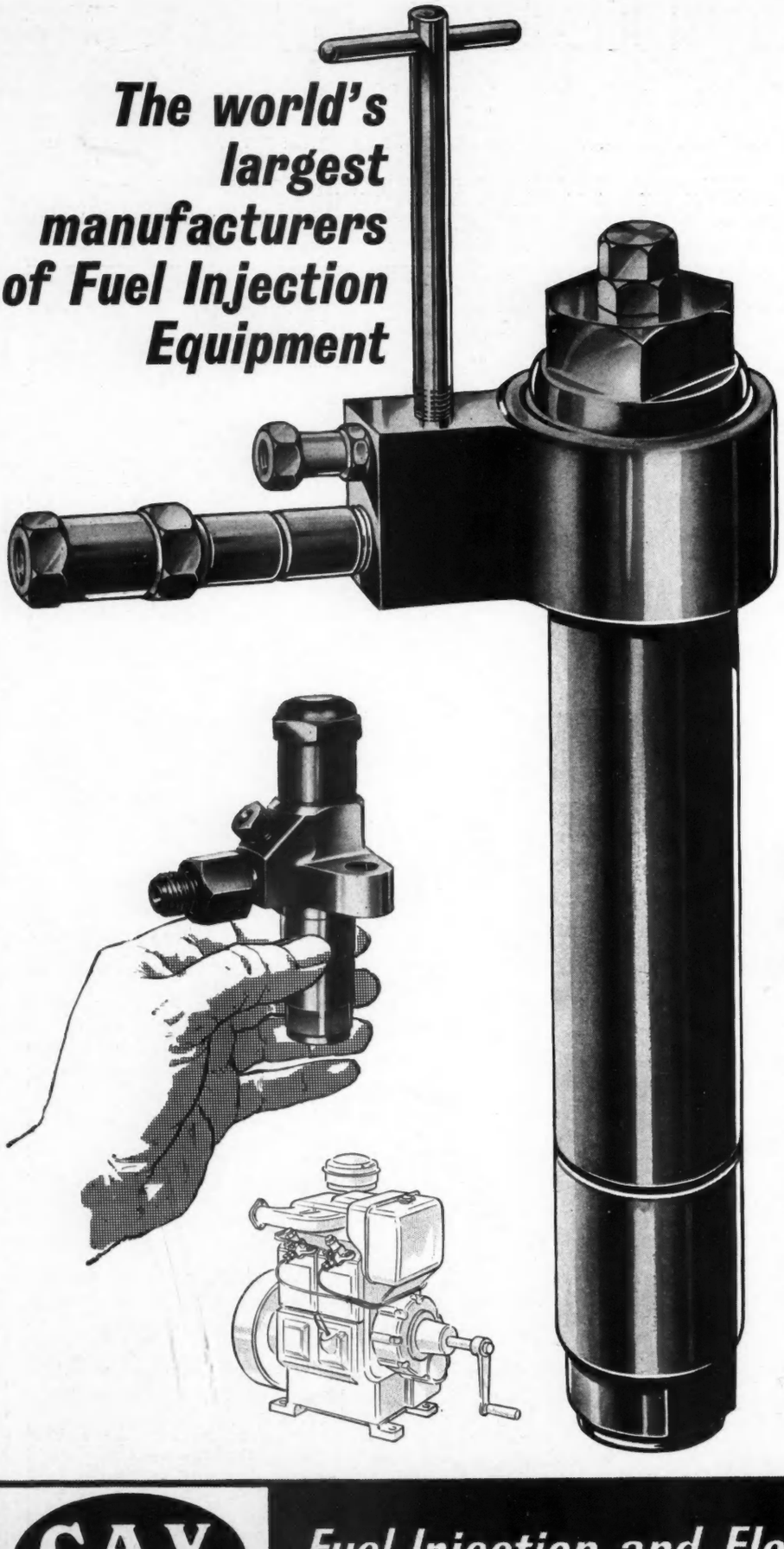

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ENGINEERING

An Illustrated Weekly Journal

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Published every Friday by Engineering Limited
35 & 36 Bedford Street, Strand, London, W.C.2
TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

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Subscription Rates for 12 months, inland and abroad £5 10s., Canada £5 5s. Subscriptions for periods of less than 12 months are based on the price of a single copy including postage [2s. 3d.]

FAWLEY

In July 1949, the 450-acre Cadland Estate on the edge of Southampton Water was covered by rolling wood and farmland; in September, 1951, the Prime Minister officially opened on that Estate " the largest oil refinery ever built at any one time anywhere in the world." Most of the major process units of the plant were in operation in July, 1951, which was six months ahead of the planned date for completion. Many people will share the opinion of the British Institute of Management that it will be to the benefit of British industry generally to know how it was done. The brief explanation is that every part of the work was planned down to the last detail, and orders were placed well ahead, and, what is probably even more important, the administrative and control methods on which the productivity of the United States is based were successfully applied on a job employing British labour.

An idea of the magnitude of the operations carried out in constructing the Fawley oil refinery on the Cadland Estate can be obtained from the description which appeared in our issue of September 28, 1951, and some understanding of the care, organising ability and hard work which lay behind the brief explanation given above can be obtained from a valuable report entitled " Construction of Esso Refinery, Fawley: A Study in Organization," prepared by Mr. A. P. Gray and Mr. Mark Abrams, of Research Services, Limited, and published by the British Institute of Management (3*s.* 6*d.*).

The refinery, built for the Esso Petroleum Company, cost £37,500,000 and one of the basic reasons for its completion in two years appears to have been the fact that it was the responsibility of a single contractor. This applies to the main plant, which was built by the Foster Wheeler Company, Limited, a subsidiary of the Foster Wheeler Corporation of New York; some ancillary units such as the administrative building and the marine terminal were built by independent contractors, but their activities had no bearing on the celerity with which the main contract was completed. The advantage enjoyed by a single contractor was that all parts of the work could be co-ordinated without reference to any other body and that labour could be moved from one job to another without ceremony.

The extensive experience of the Foster Wheeler organisation in the construction of oil refineries was clearly an important factor; planning and the ordering of material were carried out in the light of prior knowledge. The building of this particular plant in England in record time was, however, greatly assisted by exceptional help from the Treasury. It was realised that a refinery capable of producing some 6,500,000 tons of petroleum products per year would do much towards eliminating the necessity for the expenditure of large sums on imports. As a result, permission was without difficulty obtained for the purchase of plant and material in the United States on a scale which some responsible for other capital projects may envy. Handling and other equipment was provided on a lavish scale; nothing facilitating speed of erection was grudged. Time was money.

Satisfactory labour relations were established and maintained. In co-operation with the Confederation of Shipbuilding and Engineering Unions, all labour was engaged on a single basis and a common wage rate was established for all crafts, regardless of trade or the union to which the men belonged. There was a guaranteed week, but neither piece rates nor bonuses. The common wage lessened friction between different crafts; all were on the same basis. The arrangement worked well; up till July, 1951, only 0·006 per cent. of man-hours had been lost because of labour disputes. The only significant stoppage was due to electricians, members of a notoriously difficult union. The total number of men engaged over a period of 25 months was 10,380; turnover was fairly low. Southampton, 17 miles away, could supply only a fraction of this number and workers were recruited from all over the country. Many men had to live at a distance and travelling facilities were provided and paid for. Living accommodation was also arranged at the site, of a somewhat higher standard than is usual in this country.

All other considerations apart, however, it would appear that the skilled American supervision over the large and miscellaneous labour force was a major factor in the speed with which the plant was built. The whole work was under the control of Mr. R. J. Cole with a team of 70 American supervisors. These supervisors were all skilled craftsmen as well as being men of high status and extensive responsibilities. They kept the same hours as the workpeople and were always ready to lend a hand in actual operations. They and Mr. Cole were approachable by anybody at any time. Control was strict and good time-keeping was expected and insisted on. Any man who arrived late on three occasions without adequate reason could be dismissed. Checkers went round the site twice a day to see that the men were actually on the job, and in wet weather workers were not allowed to take shelter until it had been decided that work should stop and a whistle had been blown. Absenteeism was

reduced by the introduction of a 2*d.* per hour attendance bonus, payable only if a full day was worked.

It is emphasised in the report that the supervisors got on well with the men. They came to be looked upon as "helpers" not "policemen." They did something towards imparting to British workmen some of the interest and enthusiasm which American workmen show in the progress of the job on which they are engaged and to which high American productivity owes so much. With reluctance, the American controllers agreed to the introduction of a tea break. This characteristic British institution might serve as a symbol indicating the difference between the attitude of mind which places the job in hand in the front position and that which subordinates it to personal considerations.

* * *

Weekly Survey

SAVING FUEL

At the Old Centralians luncheon held in London on March 15, the speaker was Sir Harold Roxbee Cox, Chief Scientist, Ministry of Fuel and Power. He dealt with the efficient use of conventional fuels and the possible developments of unconventional ones. The use of atomic energy he omitted on the grounds that it was not yet ready for use. Sir Harold said that the present average efficiency of the coal-burning steam-turbine power-station was 22 per cent. but he looked forward to a maximum of 35 per cent. when all the old stations had been replaced. He estimated that the coal-burning gas-turbine station might give a figure of 45 per cent.

Commenting on the two gas-turbine cycles, Sir Harold said that a closed-cycle machine had been running satisfactorily for 200 hours using coal slurry as fuel and another for 1,000 hours burning peat. Open-cycle machines had run on coal and also on gas from a gas-producer working at six atmospheres pressure. It was estimated that the new gas-turbine locomotive would have an efficiency of 11 per cent.

Other sources he mentioned were the tides, the sun (a plant was working in the south of France) and the wind; two experimental windmills each producing 100 kW were under trial. Methane from coal mines was also being used, either by draining from the coal direct, or from the ventilating air from the up-cast shaft.

Answering questions put to him, Sir Harold said that waste gases from oil refineries were being used where possible, but fluctuations in quantity made this very difficult. Underground gasification of coal was proving quite practicable and the electric linkage system had just proved very successful. Burning peat in power stations was only economical if transport costs were low. Alternatively, it was proposed to have small mobile gas-turbine units which would be moved forward as the peat was used; an experiment of this sort would probably be in progress within twelve months. The storage of power developed by wind or tide was still a problem but one suggestion was to use the power generated at peak periods to electrolyse water and then to store the resulting hydrogen and oxygen.

* * *

BUCKLING OF RAILWAY TRACK

Four points emerge from the report of the chief inspector of railway accidents on the derailment of the "Royal Scot" near Abington, Scottish Region, last August. They are: that buckling of track in hot weather is a very likely happening unless all the precautions laid down in the standard instructions to length gangers are put fully into effect; that the operation of adjusting flat-bottomed track for creep, involving as it does the drawing of 144 spikes in each 60-ft. rail length and later re-driving, is beyond the capabilities of the permanent-way length gangs as at present constituted; that, while in general standing instructions are carried out, there is fairly widespread failure to appreciate the consequences of not fulfilling the instructions; and, fourthly, that, in the event of an accident, the new standard designs for carriages, with all-steel welded body shells welded to strengthened underframes, are sufficiently strong, so far as the reduction of fatal accidents to the passengers is concerned, to withstand derailment at speed.

The north-bound "Royal Scot," running from Euston to Glasgow and comprising 13 bogie coaches hauled by a Pacific-type engine, was derailed while travelling at 60 miles per hour, the track buckling laterally under its passage. The official inquiry showed that failure of the track was brought about by not paying attention to three fundamental points of track maintenance which had been stressed repeatedly in instructions for the prevention of track distortion during hot weather.

At the point at which the accident occurred, the track consisted of a curve of 57 chains radius on a falling gradient of about 1 in 300. Derailment, as shown by the marks of the wheel flanges crossing the head of the rails, occurred a few yards after a change from flat-bottomed rails to the lighter bull-head rails. In evidence it was stated that the F.B. track had crept about 2 in. during the preceding months but that the rails had not been drawn back, the task being beyond the capacity of the length gang. It was also stated that many of the expansion gaps between the rails on the F.B. track were completely closed, the shade temperature being about 75 deg. F. Nevertheless, the expansion gaps on the B.H. track were of standard width and it follows, therefore, that these rails were not expanding freely due to tight fish-bolts, and contained considerable compression stresses. Furthermore, the ballast in the area had been opened up and partially removed in an effort to clean it; the support of fully consolidated ballast was therefore lacking, and the opinion is expressed in the report that the track might have held its alignment had the ballast been packed properly. Though it was said in evidence that the train was running satisfactorily up to the moment of derailment, the condition of the "top" of the track preceding the point of the derailment was "by no means perfect" and it would appear probable that the train was rolling somewhat when it moved on to the unstable B.H. track. It is estimated that the track distorted 20 in. out of line under the passage of the train.

The report (price 2*s.* 6*d.*) is published by the Stationery Office on behalf of the Ministry of Transport and Civil Aviation.

* * *

THE ROYAL AIRCRAFT ESTABLISHMENT

The British aircraft industry is well aware of the large part played by the Royal Aircraft Establishment at Farnborough in the development of successful aircraft, both military and civil – a part that has tended to become more and more important as aircraft have grown in complexity. Possibly, however, passengers travelling in British transport aircraft do not yet realise to what extent Farnborough has contributed to their safety and convenience – not only in the more obvious fields of aerodynamics and structural strength, but also in equipment, instruments and air-traffic control aids. Much of what is now standard equipment in aircraft and at airports was developed in the first place at Farnborough. Some of the work initiated at Farnborough has still wider implications of benefit to a broad range of manufacturing industries. Some of this work was described recently in a lecture given by the Director of the R.A.E., Professor A. A. Hall, to the Royal Society. A summary of this lecture is given on page 372.

* * *

Letters to the Editor

SECRET BALLOTS IN INDUSTRIAL DISPUTES

Canadian Practice

SIR, I was very interested to read the labour note in your issue of January 29 last concerning secret ballots in industrial disputes and, in particular, the conclusion that their use was not desirable. This is, perhaps, but one additional example of how different conditions alter decisions concerning recommended policies, but it may be of interest to you to know that secret ballots prior to strike action are required in four of our provinces, and that experience has been such that it is likely that other provinces will follow suit.

Since work stoppages in a particular company or industry may affect the well-being of large sections of our population throughout the country, it is accordingly especially important that votes concerning strike action should represent the voter's personal feelings and considered thinking. The protection afforded to voters by secret ballots, when voting on important issues, is, of course, fundamental to our democratic principles and practices, and is already contained in the labour-relations legislation of our federal and provincial governments, with regard to the certification of trade unions as collective-bargaining agents and in connection with certain other matters.

There have been occasions in the past when union members were, in effect, coerced into supporting leaders who advocated strike action, and rank and file members may sometimes be concerned at the possible consequences resulting from voting publicly against their executives. It might be added that, while lockouts are relatively uncommon, employers in our industry are more than willing to follow secret balloting practices in cases where group agreements exist with trade unions.

Yours sincerely,
S. D. C. CHUTTER,
Acting Manager.

Canadian Construction Association,
384 Bank-street,
Ottawa 4, Canada.
March 12, 1954.

[In the labour note referred to, we concluded by stating: "That the Government is not favourably inclined towards proposals for the enforcement of secret ballots was apparent from their attitude to a Parliamentary question asked on January 19, when the Prime Minister stated that he would not introduce legislation to make strikes illegal until such time as secret ballots of workpeople, under Government auspices, had been taken. He said that there was no intention of departing from the established tradition in this country, under which the trade-union movement was left to manage its own affairs."]

A MEETING FOR YOUNG ENGINEERS

Engineering in the Iron and Steel Industry

A meeting of junior engineers will be held under the auspices of the Iron and Steel Institute at Buxton, Derbyshire, from Monday to Thursday, April 26 to 29. Mr. C. H. T. Williams, chairman of the Iron and Steel Engineers Group of the Institute, will be in the chair.

The object of the meeting is to provide an opportunity for the younger engineers and operators in the iron and steel and associated industries to discuss engineering problems and visit works of interest. Any young engineers falling in this category will be welcome at the meeting, provided they are below the age of 35, whether they are members of the Iron and Steel Institute or not.

The meeting opens at 3.30 p.m. on Monday April 26, when four papers will be presented and discussed during the afternoon and evening, namely, "The Starting Up of an Automatic Repeating Hoop Mill," by Mr. D. W. Ainsbury, of Barrow Steel Works, Limited; "The Installation and Commissioning of the Electrical Equipment Associated with a Bessemer Converter Plant," by Mr. J. S. Reed of the Consett Iron Company, Limited; "The Erection and Commissioning of a Large Combined Ingot Stripping, Flanging and Drawing Crane," by Mr. W. D. B. Glass, of Colvilles, Limited; and "The Commissioning of a Reheating Furnace," by Mr. B. L. Nixon, of the Round Oak Steelworks, Limited, and Mr. A. Hunter, of Stein and Atkinson, Limited.

Tuesday and Wednesday, April 27 and 28, will be devoted to all-day visits to the Davy and United Engineering Company, Limited, Sheffield, the Park Gate Iron and Steel Company, Limited, Rotherham, the English Steel Corporation, Limited, Sheffield, and the Steel, Peech and Tozer Works, Rotherham. On Thursday, April 29, a lecture on the "Iron and Steel Industry in the United States" will be delivered from 9.30 to 11.30 a.m.

Stencilled advance copies of the papers to be presented on April 26 will be distributed beforehand to all those attending the meeting. Accommodation has been reserved at the St. Ann's Hotel (where all the technical sessions will take place) and at the Old Hall Hotel, Buxton. The cost of accommodation and meals will be approximately 34*s.* per person per day. The conference fee, which will cover transport and other charges connected with the works visits, is £2 5*s.*

Application on the prescribed registration forms should reach the secretary of the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1, not later than March 26.

* * *

SMOKE IN CITY OF LONDON

Mansion House Conference

Following representations by property owners and others in the City of London regarding the nuisance caused by smoke, a whole-day conference will be held on "Smoke Reduction in the City of London (Solid and Liquid Fuels)" at the Mansion House, London, E.C.4, on Friday, March 26. The conference has been arranged jointly by the Coal Utilisation Council and the Combustion Engineering Association, with the object of showing how the emission of smoke can be reduced by the use and selection of suitable fuels and appliances.

The morning session, under the chairmanship of Mr. J. Stanleigh Turner, President of the Coal Utilisation Council, will commence at 10 a.m. and will be opened with addresses by the Lord Mayor, Sir Noël Bowater, Bt., M.C., and Captain (E) W. Gregson, R.N.R., M.I.C.E., past-president of the Institution of Mechanical Engineers. Subsequently, there will be a discussion on "The Available Fuel," opened by Sir John Charrington, and one on "Smoke Reduction in Small and Domestic Appliances," opened by Mr. W. C. Moss.

The afternoon session will be held under the chairmanship of Mr. B. E. A. Vigers, M.A., A.M.I.C.E., President of the Combustion Engineering Association, and will commence at 2.15 p.m. The theme will be "Central Heating" and addresses will be given by Mr. W. H. Gamble on "Sectional Boilers," and by Mr. J. R. Kell on "Shell and Water-Tube Boilers," after which a discussion will take place.

Admission will be by ticket only, obtainable from the conference office, 6 Duke-street, St. James's, London, S.W.1. (Tel. WHItehall 5536.)

* * *

Obituary

COLONEL SIR PAUL GUETERBOCK

Distinguished Metallurgist

It is with regret that we record the death of Colonel Sir Paul Gueterbock, K.C.B., D.S.O., M.C., T.D., D.L., J.P., which occurred on March 8 at his home at Abbots Leigh, near Bristol.

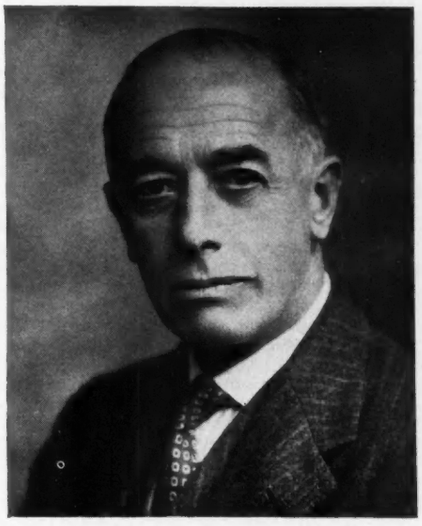
Paul Gottlieb Julius Gueterbock, who was managing director of Capper Pass and Son, Limited, tin and lead smelters, Bristol, and a past-president of the Institute of Metals, was the son of Alfred Gueterbock and was born on September 13, 1886. He was educated at Rugby School, where he was a Scholar, and afterwards went to Trinity College, Cambridge, where he was a student of Mr. C. T. Heycock, the pioneer metallurgical physicist. In 1909, soon after graduating, Gueterbock joined the staff of Capper Pass and Son, Limited, and spent the subsequent five years on the investigation of the constitution of antimony-lead-tin alloys and the development of processes for the treatment of low-grade and complex tin ores. After 1919 he initiated and developed processes for the recovery and refining of tin. In 1924 he was elected a director of his firm and was made managing director in 1937. He was also chairman of Victor G. Stevens, Limited, Gateshead-on-Tyne, and George Pizey and Son, Limited, London, E.10, and served as chairman of the British Non-Ferrous Smelters Association from 1945 to 1950. He was elected a member of the Institute of Metals in 1922 and served as a member of Council from 1940 to 1943 and as a vice-president from 1943 to 1946. He was President of the Institute from 1946 to 1948. Colonel Gueterbock was elected a member of the Institution of Mining and Metallurgy in 1929 and a Fellow of the Institution of Metallurgists in 1946.

Colonel Gueterbock was an active member of the Auxiliary Forces. For many years he was chairman of the Gloucestershire Territorial Army and Air Force Association and County Army Welfare Officer for Gloucestershire. He was created a C.B. in 1943, and, in 1946, appointed Deputy Lieutenant for the County of Gloucestershire. He was an additional A.D.C. to King George VI from 1947 to 1952 and to Her Majesty the Queen after 1952. He was created a K.C.B. in 1949.

* * *

We also regret to record the deaths of the following :

MR. ALFRED JAMES, at Brightstone Rectory, Isle of Wight, on March 6, at the age of 77.



The Late Colonel Sir Paul Gueterbock.

Mr. James was a former chief mechanical engineer of the Assam Bengal Railway.

MR. A. E. DARLINGTON, at Liverpool, on February 28, at the age of 68. He had been employed by the British Thomson-Houston Co. Ltd., for 43 years, having joined their Manchester office in 1911. In 1950, owing to ill health, Mr. Darlington resigned the post of manager, lamp and lighting sales, Liverpool office, but remained with the company in an advisory capacity. He was a past chairman of the Liverpool branch of the Illuminating Engineering Society.

MR. W. H. MOORE, at his home at Chandler's Ford, Hampshire, on February 13, at the age of 75. He retired in April, 1952, from the position of contract manager to Pirelli-General Cable Works, Limited.

ENGINEER REAR-ADMIRAL J. E. G. CUNNINGHAM, M.V.O., at the Royal Naval Hospital, Plymouth, on March 7, at the age of 75. He entered the Navy in 1894 and retired in 1932.

* * *

INSTITUTE OF WELDING

Spring Meeting at Porthcawl and Bristol

With the co-operation of its South Wales and South-Western Branches, the Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1, has arranged to hold its 1954 spring meeting at Porthcawl and Bristol from Wednesday, April 28, to Saturday, May 1.

The proceedings will open with an informal gathering and exhibition of technical films at the Grand Pavilion, Porthcawl, Glamorganshire, on the evening of April 28. On the morning of the following day, April 29, there will be a technical session in the Grand Pavilion, at which papers will be read by Dr. L. Reeve on "Steelmaking and Welding," and by Dr. C. L. M. Cottrell on "Hydrogen: Barrier to Welding Progress."

On the morning of April 30, there will be a technical session at the Grand Hotel, Bristol, at which two papers will be read on "Nitrogen-Arc Welding of Copper"; one by Mr. E. Davis and Mr. C. A. Terry, and the other by Dr. K. Winterton. During the afternoons, members will have the choice of a number of visits to works.

The meeting will conclude with a technical session at the hotel on the morning of May 1, at which papers will be read by Mr. F. G. C. Sandiford on "Welding in the Aero-Engine Industry: Reflections on Organisation by a Production Engineer," and by Dipl. Ing. F. Koenigsberger on "Welding as a Career."

SAFETY IN SHIPS*

By Captain J. P. Thomson, O.B.E.

The eastern part of the Mediterranean saw the beginning of ships and their early growth, the Romans and Greeks having their part in turn. The growth of the ship in the north of Europe was much later; probably one of the earliest was that found at Nydam, Denmark, in 1863, which was probably built about A.D. 200. The Vikings settled in Iceland and Greenland by A.D. 1000; their ships were better designed and constructed to stand up to the weather of the Atlantic than were those of the Mediterranean. The ships of Columbus (1492), Vasco da Gama (1498), Magellan (1519), and Drake (1577) had not improved very much upon those of the Vikings.

The Corporations of Trinity House at Deptford, Hull and Newcastle originated well before the Sixteenth Century, the first Charters being granted by Henry VIII. These Corporations very early established a great service in the provision of lights, beacons and buoys to mark dangers, a pilotage service, etc. Trinity House has continued this great work to this day. King Charles I, in 1646, separated the Royal Navy from the Merchant Navy, and Charles II helped the Merchant Navy by forming the Board of Trade and by the Navigation Laws of 1666. In 1765, the marine chronometer came into being through the genius of John Harrison. In 1845, certificates of competency for masters and mates were instituted, and in 1850 they became compulsory. One hundred years ago, in 1854, the Merchant Shipping Act was passed, which changed tonnage measurement with a view to improving the form of ships. The question of proper loading was left to the master, as, in law, it still is to-day, though the weight of cargo that he may carry is fixed by a loadline.

The load draught of ships was shown on a list of ships printed by Edward Lloyd, of Coffee House fame, in 1774. This list afterwards became Lloyd's Register. The practice continued until 1834, when Lloyd's Register became a separate society from the underwriters of Lloyd's. At the same time, the Committee of Lloyd's (the underwriters) proposed, as a guide to safe loading, that the freeboard should be set down on each side of the ship amidships, the amount of free side from the deck being a quarter of the depth of the hold. This rule proved to be a good guide, but experience showed it to be lacking in some ways.

The attention of the Board of Trade was drawn to the excessive losses of ships by the Newcastle Chamber of Commerce, who considered that the main causes of losses were improper equipment and unseaworthy conditions, as well as the incompetence and carelessness of those in command. In a report sent to the Associated Chambers of Commerce in London in 1870 by James Hall, of Tynemouth, a shipowner, he gave several instances of overloading. The report was adopted and sent to the Board of Trade, who asked the Government to consider the question of a maximum loadline for sailing and steam ships. In the same year, the Institution of Naval Architects also sent a report to Parliament.

The year 1870 saw further activities. Samuel Plimsoll, M.P. for Derby, interested himself in the question, making use of Hall's work, and met with such success that, to this day, seamen call the loadline the Plimsoll mark and have not heard of the name of James Hall. In 1870, also, Lloyd's Register first fixed the loadlines for a particular type of ship.

FREEBOARD REGULATIONS

In 1871, a Merchant Shipping Code Bill was introduced which stated that the draught of water should be shown at the bow and stern, and put on record. Officers of the Board of Trade were required to prevent ships from going to sea if they considered that any defect made the vessels unseaworthy. The Bill was not passed until 1873, but it then gave the officers of the Board of Trade power to detain overloaded or improperly loaded vessels. The working of this Act led to endless problems and a Royal Commission on unseaworthy ships was appointed. This was followed by the Merchant Shipping Act of 1875, which required improved markings of loadlines and of decklines, and that the freeboard should be written into the agreement with the crew. The same Act also dealt with the stowage of cargo. It was passed only for one year, but was carried again in 1876.

The rules still presented difficulties, and the Board of Trade called a conference with Lloyd's Register and the Liverpool Registry. Though agreement on the amount of freeboard was not reached, it was concluded that such measurement should take into account the construction and strength of the ship, the ratio of the enclosed space above the waterline to that below, the form and proportions as well as the sheer, the strength of the deck fittings, and the height of the weather deck above the water. The proposal was based on the ratio of the buoyant space above water to that below, the first condition (that of strength) being obtained when the vessel was built to Lloyd's Rules.

Lloyd's Register continued their work and, in 1882, issued tables for the freeboard of all kinds of vessels, which owners could use if they wished. The idea was welcomed and by 1890 some 2,200 ships had been marked by Lloyd's Register. In 1890, the first Loadline Bill was passed and became part of the Merchant Shipping Act. The strength was fixed on the 1885 Rules of Lloyd's Register and freeboards could be marked by the Board of Trade, Lloyd's Register, the British Corporation and the Bureau Veritas. These Rules of 1890 represented the best sea practice of about the period 1872-82, and the increase in safety, particularly since 1890, is due, in part, to having a loadline.

THE MERCHANT SHIPPING ACT, 1894

In 1894, the Merchant Shipping Act, in 740 sections, became law. Enactments and repeals have been introduced during the past 60 years, and it is suggested that further amendments and consolidation are now due. It is probably the best guide in existence on maritime statutory matters. Sections 464 to 491 deal with Special Shipping Inquiries and Courts; their jurisdiction extends to every quarter of the globe where British ships and seamen may be found, and may be exercised on the high seas and in places abroad where no other British Courts have power to function. They are primarily administrative Courts of Inquiry, created to assist the Board of Trade in their duty of preserving a reasonable standard of safety of life and property at sea. They owe their origin to the Mercantile Marine Act of 1850 and, therefore, have been in existence and doing good work for more than 100 years. Between 1850 and 1930, some 8,000 inquiries were held. The Courts are not Criminal Courts, but tribunals to find out exactly what happened. Generally, they make recommendations to prevent a recurrence. The reports are circulated in shipping circles and may be obtained from H.M. Stationery Office. These inquiries, and the publicity given to the findings, have been a great asset to the shipping industry.

It was not until 1894 that the Board of Trade issued Sections 446 to 450 of the Merchant Shipping Act, dealing with the carriage of dangerous goods and explosives in ships. In later years, however, science has produced many grades of dangerous goods, notable among them the products of the petroleum technologist. Further guidance was needed by the shipper and the mariner, and the Ministry of Transport have now published the report of the Departmental Committee appointed to consider the existing rules.

In 1898, the Board of Trade called together a small committee to add to the rules of 1885 the requirements of special types, such as the turret ship, and brought in a rule for more freeboard for ships under 330 ft. long. Germany had established freeboard rules in 1903, giving less freeboard in some respects than the British tables, and this resulted in the appointment in 1906 of a similar committee to that of 1898, to consider the position once more. This committee made some reductions in freeboard, which remained a subject of public debate for some time. The effects of the reductions were examined in 1913 by comparing casualties before and after the change, and hearing the experiences of owners, masters and crews, and of the registration societies which fixed the freeboards. The committee found that the reductions of 1906 had not increased the losses.

This was the position in 1913, when another loadline committee was appointed. The loss of the Titanic in April, 1912, led to a convention in London in November, 1913, of representatives of the principal maritime countries, when certain rules for safety at sea were agreed. This convention dealt with sub-division, lifeboats for all, and ice patrols in the North Atlantic, but confined itself almost entirely to passenger ships. War broke out in 1914 and the Convention was not adopted internationally, though Britain adopted its main provisions. With some alterations, the freeboards of 1930 were much the same as those of 1880; and, although the international Convention of 1930 made some changes, for ordinary cargo vessels the previous practice maintained.

The regulations for preventing collisions at sea came into operation in 1863. Certain rules of navigation had long been recognised more or less in practice, but from 1863 the regulations became compulsory for British ships. They were subsequently adopted by every maritime nation of any importance.

SEAWORTHINESS

Seaworthiness is a wide term and embodies many features; first, the strength of the ship's structure. After many years of study, Lloyd's Register introduced "Lloyd's Numbers" for regulating scantlings, frame spacings, the number of keelsons and of side stringers, etc. With scientific development, this method became insufficient; so the basis was changed, and the scantlings for the wide range of sizes and types of ships in existence to-day are laid out in detailed tables. In general, they are related to basic dimensions and, where necessary, to a basic moulded depth. In recent years, cases of major and minor structural failures have attracted attention. The classification societies have investigated these and have done a great deal of research work. The failures were not confined to one class of ship, but they were more numerous in certain types, mainly in ships built abroad during the war years. Steps have been taken to guard against their recurrence.

STABILITY

Ships at sea are subject to heeling forces, such as the effect of wave motion, wind pressure, ingress of water, etc. The naval architect aims to design the ship so that she can resist them. Methods for ascertaining stability by calculation, measurements, and inclining tests have been known for many years, but, notwithstanding that knowledge, as recently as 30 years ago it was exceptional to find on board ships information that would enable the stability under varying conditions of loading and ballasting to be determined otherwise than by trial and error. In 1928, the Board of Trade took the matter up with shipowners and builders, and it was agreed that all new British ships, built in United Kingdom yards, should be put through an inclining test, and that the stability information should be passed on to the masters. The agreement was voluntary, and as the data to be supplied were not defined, owners differed in their views of what information should be given to the shipmaster.

* Thomas Gray Memorial Lecture, delivered to the Royal Society of Arts, London, on Wednesday, March 10, 1954. Abridged.

In 1948, the International Convention on Safety of Life at Sea carried the matter farther, laying down that ships must be inclined on their completion and the elements of their stability determined, and that the master should be supplied with such information on the subject as is necessary to permit efficient handling of the ship. The Merchant Shipping Act, 1949, empowers the Minister of Transport to make rules concerning the information to be supplied.

The ship of to-day is built under the supervision of the classification society's and the owner's surveyors, and, to retain her class, must be surveyed every four years. The strength of the structure, if maintenance and surveys have been kept to the requisite standard, will be in order; but there are other features – hatches, ventilators, scuttles, doors and ports, deck openings, etc., which require the attention of the deck officer. Losses have occurred through defects in these, and have been the cause of additions to the freeboard survey rules. The freeboard certificate is granted after inspection by the classification society and/or the Ministry of Transport, and is normally valid for five years. The ship is inspected and the certificate endorsed annually by the assigning authority.

SUBDIVISION

Subdivision of the hull by transverse bulkheads and by the fitting of double bottoms has made an important contribution to safety. The double bottom in all large cargo and passenger vessels extends from the after peak bulkhead to the fore peak bulkhead. Sailing vessels had only one transverse bulkhead, fitted forward; but the risk of fire in steamers led to the fitting of two additional watertight bulkheads to divide the machinery space from the cargo holds. All steamers, therefore, have a minimum of four bulkheads, or three if the machinery is placed aft. A ship 285 ft. long would have an additional bulkhead, and, for greater lengths, more would be fitted. For passenger vessels, the subdivision is required to be such that the ship will remain afloat with one, two or three adjacent compartments flooded.

The greatest advantage in subdivision is seen in the tanker, which, in a length of 460 ft., may have as many as 17 transverse bulkheads and two longitudinal bulkheads. There are also double bottoms under the machinery spaces and a deep tank forward. The construction is a near approach to an unsinkable ship, and experience has shown that, when in ballast, a tanker will take a great deal of punishment before sinking.

LOSSES OF SHIPS

The total loss of 90 ships during 1953, with a total gross tonnage of 341,877, might be regarded as serious; but there are over 90 million tons of shipping, and the percentage of tonnage losses is small—only 0·37 per cent. A comparison of the figures of partial loss – 7,272 cases – and the total loss of 90 shows the latter to be 1·23 per cent. of the total casualties. The total figures for the three previous years are: 1950, 6,900; 1951, 7,794; and 1952, 7,781. The average was 7,491, and the figure for 1953 – 7,272 – is an improvement on the average of the three previous years of 2·92 per cent.

In the total loss figures, four stand out rather boldly; they are strandings, collisions, founderings and abandonments, and fire and explosions. Under these four headings, no less than 88·88 per cent. of the losses are grouped. Strandings account for 38 ships, collisions for 18, founderings and abandonments for 15, and fire and explosions, 9. The British Commonwealth losses by these four causes are 13·33 per cent. of the total loss. Although the figures for loss by fire or explosions are comparatively low, the risks of fire are always present, more or less, in a ship, whether at sea or in port. Perhaps the greatest risk is when the vessel is under repair.

WEATHER

It was long a dream of weather men to have a chain of ships across the ocean to report surface weather and to take balloon soundings of the upper air. This has been achieved, and in the North Atlantic there are ten such ships on station the year round. In addition, there is a voluntary service of mobile ships in all oceans; the Air Ministry's Marine Department receives regular reports from 1,780 selected ships, 440 supplementary ships and 250 others, a total of 2,470. In addition, the International Convention on Safety of Life at Sea, 1948, makes it a requirement that, in emergencies or hurricanes, all ships in the area shall send in reports.

Among the general aids to navigation, the astrolabe and the magnetic compass, and their uses, were known in 1492, in the days of Columbus; though whether Columbus used the astrolabe in his four voyages to America is debatable. He certainly used a magnetic compass, and kept two reckonings. We have come a long way since then. The Admiralty Hydrographer publishes and keeps up to date over 7,000 charts of the world. The Masters and Elder Brethren of Trinity House have done a great service in providing lighthouses, beacons and buoys in the British Isles.

NAVIGATION BY RADAR

The Twentieth Century has witnessed great developments in wireless telegraphy. It has provided distress signals for ships, then time signals for checking chronometers at sea, echo sounders and direction finders, and then radar, Decca, Loran, and Consol. Radar to-day has become almost a standard fitting. The Decca Navigator is a position-finder, by which the seaman in coastal waters may fix his position in about 10 seconds by using a special lattice-line chart on which a pin-point intersection can be placed by reading a number of dials.

Loran, a long-range position-finding device, operates on the time-base principle. Pulses are radiated at a constant rate, and the time interval after which they arrive at the ship is measured on a cathode-ray tube indicator. It is capable of giving a long-range fix up to 500 miles within an accuracy of three miles. The Consol system operates on the direct-bearing system, radiating a pattern of signals in dots and dashes in an anti-clockwise sequence. Up to, say, 500 miles, the accuracy is within about five miles. Gyro compasses came into use in merchant ships early in the Twentieth Century, but were regarded at first as an expensive luxury. By 1940, their real value had been established, and since then few ships of importance have not been provided with a gyro compass.

With such aids to navigation as were available in 1854, a voyage was a real adventure, even in the most seaworthy ship. It is said that risks at sea between 1890 and 1913 were reduced by 50 per cent. in British ships, and that this low risk was decreased by more than half between 1913 and 1927. The casualties in British ships were again lowered in 1950, 1951, 1952 and 1953. The question might be asked, Have we reached the point of maximum efficiency and safety at sea ? The answer is No; we must continue to develop our efforts, always remembering certain combinations of circumstances which may defy us and may continue to defy human endeavour.

PERSONAL

DR. C. DANNATT, O.B.E., M.C., M.I.E.E., has been appointed deputy managing director of the Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. MR. J. F. PERRY, A.M.I.E.E., managing director of the Metropolitan-Vickers Electrical Export Co. Ltd., has been made a director of the parent company. MR. A. C. MAIN, B.E. (Adelaide), M.I.E.E., formerly director and works manager, Trafford Park Works, has been appointed director of manufacture. MR. E. W. STEELE, M.I.Mech.E., M.I.E.E., hitherto director and general manager of works, has retired from executive duties as from March 1, but remains a director of the company.

MR. J. H. KIRBY has been appointed general manager, Smith's Dock Co. Ltd., North Shields, in succession to MR. R. H. STEPHENSON, O.B.E., who, as stated on page 293, *ante*, is retiring shortly after 54 years of service in the shipbuilding and ship-repairing industries of the North-East Coast.

MR. R. W. FOXLEE, C.M.G., C.B.E., M.I.C.E., Engineer-in-Chief, Crown Agents for the Colonies, is shortly to retire. His successor will be MR. R. W. TAYLOR, C.M.G., B.Sc. (Eng.), A.M.I.C.E., director of public works, Kenya.

MR. W. H. LAWRENCE is retiring from the Fry Group of Companies on March 31. He joined the board of Fry's Metal Foundries Ltd. in 1934.

MR. G. A. HANNAH, managing director of Pegson Ltd., has been appointed director of the parent company, Mellor Bromley & Co. Ltd., as from March 1.

MR. A. W. MONTGOMERY, joint general manager of Standard Telephones and Cables Ltd., Connaught House, Aldwych, London, W.C.2, has been elected a Fellow of the (United States) Institute of Radio Engineers.

MR. JAMES HODGE, M.A., A.M.I.Mech.E., A.F.R.Ae.S., senior consultant of Power Jets (Research and Development) Ltd., has left for New York, at the invitation of Columbia University, where he is to act as visiting professor on the subject of gas turbines.

PROFESSOR L. ESCANDE, director of the Ecole Nationale Supérieure d'Electrotechnique et d'Hydraulique, 4, Boulevard Riquet, Toulouse, has been elected Membre de l'Institut, in the Section of Membres non-Résidants, Académie des Sciences de Paris.

MR. E. A. S. ALEXANDER, MR. A. N. CLEGG, M.A., MR. MICHAEL HOPE, MR. H. H. HUTCHISON and MR. R. C. SUNLEY have been appointed to be members of the Council of Industrial Design by the President of the Board of Trade. SIR COLIN ANDERSON has been reappointed a member of the Council on the termination of his existing appointment.

MR. G. W. ROSE, O.B.E., T.D., A.M.I.Mech.E., has been appointed works manager, Car Division, Austin Motor Co. Ltd., Longbridge, Birmingham.

MR. P. R. ALLISON, M.B.E., for many years service experimental engineer, Flight Refuelling Ltd., Tarrant Rushton Airfield, Blandford, Dorset, has been appointed to the newly-created post of service manager and will take charge of a special field-servicing organisation established by the company.

MR. P. H. SCRINE, who was personal assistant to the manager, for India and Pakistan, of W. T. Henley's Telegraph Works Co. Ltd., has now been appointed assistant manager for India.

As a result of the expansion of the activities of Automotive Products Co. Ltd., Lockheed Hydraulic Brake Co. Ltd., and Borg & Beck Co. Ltd., Leamington Spa, MR. A. C. BURDON, MR. N. C. A. SPURGEON and MR. E. W. SWALES have been made deputy managing directors. Three executive directors have also been appointed, MR. E. BEAUMONT in charge of production, MR. S. M. PARKER in charge of engineering, and MR. S. W. SMYE in charge of purchasing. Moreover, MR. J. B. EMMOTT has been appointed to act as an alternate director to any member of the board.

The Skefko Ball Bearing Co. Ltd., Luton, announce that MR. E. Y. CASWELL has relinquished his duties as manager of the Bristol district to join the executive staff at the company's head office as sales manager.

MR. L. GAMSA, B.Sc., late of Sheepbridge Engineering Ltd., has been appointed sales manager of the foundry of Slough Metals Ltd., Oxford Avenue, Trading Estate, Slough, Buckinghamshire.

MR. H. D. PARSONS has relinquished his position as associate director of Enfield Cables Ltd., to take up an appointment as general sales manager, W. T. Henley's Telegraph Works Co. Ltd.

MR. W. W. W. DOWNING, A.F.R.Ae.S., M.I.P.E., former production manager, Gloster Aircraft Co. Ltd., has been promoted to the new post of works manager, under MR. R. V. ATKINSON, works director. MR. A. J. PACK is to take Mr. Downing's place as production manager, and MR. C. R. BROMAGE is promoted to be assistant production manager.

MR. J. D. GARST has been appointed operations director of the Regent Oil Co. Ltd., 117, Park-street, London, W.1. MR. O. H. FISH has been made assistant general sales manager of the company.

MR. S. S. SEABROOK is joining the Dowty Group of Companies, Arle Court, Cheltenham, as publicity manager in April.

CODES OF PRACTICE

British Standards Institution Assume Full Responsibility

As a result of discussions between the Council for Codes of Practice for Buildings, the Ministry of Works, the professional institutions concerned, and the British Standards Institution, it has been agreed that a Council for Codes of Practice shall be established within the British Standards Institution, to be responsible for all work on Codes of Practice. After March 31, the services carried out by the Ministry of Works, for the present Council for Codes of Practice for Buildings, set up in 1942 by the Ministry in response to representations from certain professional institutions, will be undertaken by the British Standards Institution.

Essentially, Codes of Practice are concerned with setting out tried and proved methods of installation, operation and maintenance of plant, machinery and equipment and the 150 Codes prepared in the past 12 years relate to such matters as the use of structural steel in buildings and in other building processes, methods of collection and disposal of surface and sub-soil water, foundations, brickwork, masonry, and the installation of gas pipes and appliances, boilers, and electrical equipment in buildings. The object of preparing such Codes is to endeavour to ensure that experience and knowledge are made widely available and that the best practices, whether long-established or involving new methods and materials, are generally adopted.

Although the British Standards Institution, hitherto, has not been the responsible authority for the preparation of the Codes, it has always been one of the consultative groups concerned and has also published the majority of the Codes, which have been regularly reviewed in our column devoted to the publications of the Institution. The Council as now constituted will have, within the British Standards Institution, the status of a Divisional Council and, in the preparation of new Codes, will consult all the professional and other interests concerned with the projects in question.

The new Council, which will come into being on April 1, will have as its first chairman Mr. A. S. Quartermaine, C.B.E., M.C., and will have a total of some 50 members appointed by professional bodies, technical institutions, Government departments and other authorities. At the outset four Codes of Practice Committees will be appointed, dealing, respectively, with civil engineering; building, construction and engineering services; mechanical engineering, and electrical engineering.

* * *

UNITED KINGDOM PRODUCTION OF PIG IRON AND STEEL

Statistics prepared by the Iron and Steel Board, Norfolk House, St. James's-square, London, S.W.1, show that the production of steel ingots and castings in this country averaged 357,200 tons a week last month. This is the highest total ever recorded for February, and compares with a weekly average of 352,400 tons in February, 1953. The corresponding annual rates of production were 18,577,000 tons in February, 1954, and 18,325,000 tons in February, 1953. The annual rate for January, 1954, was 18,737,000 tons.

The production of pig iron last month averaged 222,300 tons a week, compared with 213,500 tons in February, 1953. The corresponding annual rates were 11,557,000 tons in February, 1954, and 11,104,000 tons in February, 1953.

COLLAPSE OF THE CLIFTON HALL TUNNEL

UNKNOWN SHAFT AND INHERENT WEAKNESS RESPONSIBLE

The report* is now available on the subject of the collapse of the Clifton Hall tunnel which occurred on April 28, 1953, at Swinton, near Manchester, in the London Midland Region of British Railways. It will be recalled that at the time the roof of the tunnel failed, two houses situated over the tunnel collapsed with the loss of two lives.

The report to the Ministry of Transport and Civil Aviation has been prepared by Brigadier C. A. Langley and it is accompanied by two sheets of drawings, one of which shows in plan the open country under which the tunnel was constructed in 1846-50, the same area as now built over, a longitudinal section showing the eight shafts which had been forgotten, and a cross-section obtained from the Parliamentary plan; the other sheet gives a plan of the area immediately surrounding the collapsed houses and also shows the strengthening measures which were put in hand a few days before the collapse occurred.

UNKNOWN SHAFTS

The tunnel has a length of 1,298 yards and is perfectly straight with a height of 22 ft. 3 in. and a width of 24 ft. 9 in. It was constructed in 1850 for double-line traffic primarily serving the collieries in the Clifton Hall area. There are no ventilation shafts and the report shows the brickwork had a minimum thickness of 2 ft. 3 in.

The report states that all the tunnel records and drawings in the District Engineer's office were destroyed, either during an air raid in 1940 when the office was badly damaged, or during a fire which occurred in 1950. Information given in the report, therefore, has been compiled from the archives of the Ministry of Transport and from old plans in the Civil Engineer's office at Euston. These records have revealed the presence of eight shafts which, after serving their purpose during construction, were sealed off where they joined the tunnel, then filled and subsequently lost sight of.

Excavations have verified the existence of four shafts, two others appear to be under existing buildings, one other, which should be under a playing field, cannot be located, while the eighth is the one which collapsed into the tunnel together with the two semi-detached houses immediately above it.

PRIOR REMEDIAL ACTION TAKEN

The report shows that on April 13, 15 days before the collapse, a ganger found a small amount of brick rubble in one of the tracks and immediately reported the occurrence. Prompt action by responsible officers was then taken and detailed inspections were made by the District Engineer, Mr. A. Lloyd Owen, and his staff, and on April 14, instructions were given for the profile of the tunnel to be measured that supporting ribs, made from rails, might be fabricated and fitted. Manufacture was commenced but some difficulty in placing them in position was experienced due to inequalities in the brickwork; before the work could be completed the collapse occurred.

This collapse and failure of the roof of the tunnel is not attributed to a mining subsidence but to inherent weakness; moreover, it is quoted from a report dated 1850 that considerable difficulty was encountered during construction. Brigadier Langley concludes with the view that there was nothing in the condition of the brick-lining of the tunnel " to suggest that any part of it was in imminent danger of collapse " and, further, " I am confident this would not have occurred but for the presence of the unknown shaft."

The report also recommends that all tunnel records should be reviewed and that any special features should be brought to the notice of the maintenance and examining staff. It also points out that the position of disused shafts should be permanently marked in the tunnels themselves, so that these places can be particularly watched.

* *Ministry of Transport and Civil Aviation. Report on the Collapse of the Clifton Hall Tunnel.* H.M. Stationery Office, Kingsway, W.C.2. (1*s.* 9*d.* net.)

A SWEDISH STEELWORKS

OUTPUT INCREASED BY 50 PER CENT.

A series of extensions to the plant at the Fagersta Steelworks of Fagersta Bruks A.B., Sweden, have recently been completed. They have been spread over seven years and have resulted in increasing the production of high-grade steel ingots and various other products to 155,000 tons last year. This total is 50 per cent. higher than was the output for 1939. The Fagersta Steelworks constitute the parent plant of four other installations which were amalgamated during the years 1927 to 1929. The other plants are the Kloster, Forsbacka, Horndal and Dannemora Works. Fagersta is situated in the heart of Bergslagen, the rich iron-ore country in Central Sweden which has been the site of mining activities and iron-smelting operations since the 13th Century and perhaps earlier. Some 200,000 to 300,000 tons of the Bergslagen ore are mined annually in the company's mines.

The iron and steel installation at Fagersta now comprises three blast furnaces, two 20-ton Bessemer converters, an 80-ton open-hearth furnace, which is stated to be the largest of its type in Sweden, a 25-ton electric-arc furnace and three high-frequency induction electric furnaces. New strip, wire-rod, and cold-rolling mills and an automatic plant for producing electrically-welded tubes have also been installed. In the latter plant, strip is bent round to form a tube and the two edges are then welded together, after which the flash is removed and the tubes sawn into specified lengths. The outside diameters of the tubes manufactured range from 108 mm. (4¼ in.) to 13 mm. (½ in.), for plain carbon steels, and from 60 mm. (2·36 in.) to 6 mm. (0·236 in.) for stainless steel.

Various departments of the Fagersta works also produce steels for ball bearings, springs and tools and, in addition, have entered the powder-metallurgy field and manufacture tungsten-carbide tool tips for rock-drill bits and other applications.

CONTRACTS

Passenger and Cargo Liner. Vickers-Armstrongs Ltd., Vickers House, Broadway, London, S.W.1, have received an order from Canadian Pacific Steamships Ltd. for a 22,500-ton passenger and cargo liner, to be built at the firm's shipyard at Walker-on-Tyne. She will be a sister ship to the Empress of Britain, which is already under construction at Fairfields on the Clyde. The name of the new ship has not yet been chosen. She will have a length, between perpendiculars, of 600 ft., a breadth moulded of 85 ft., a depth moulded of 48 ft. and a draught of 29 ft. Her propelling machinery will consist of direct-reduction geared turbines to be built by Vickers-Armstrongs Ltd., Barrow-in-Furness. These are being designed to develop a maximum of 30,000 s.h.p., giving a service speed of 21 knots.

Iron-Ore Survey from the Air. Hunting Geophysics Ltd., 29 Old Bond-street, London, W.1, have been awarded a contract for a large-scale aeromagnetic survey of the iron-ore resources of the Philippine Islands. The survey is a project sponsored by the Philippine Council for United States Aid and the Foreign Operations Administration. Flying for the survey, which will commence shortly, is to be carried out by a twin-engined Percival "Survey Prince" aircraft equipped with an airborne magnetometer registering variations in the earth's magnetic field with great accuracy.

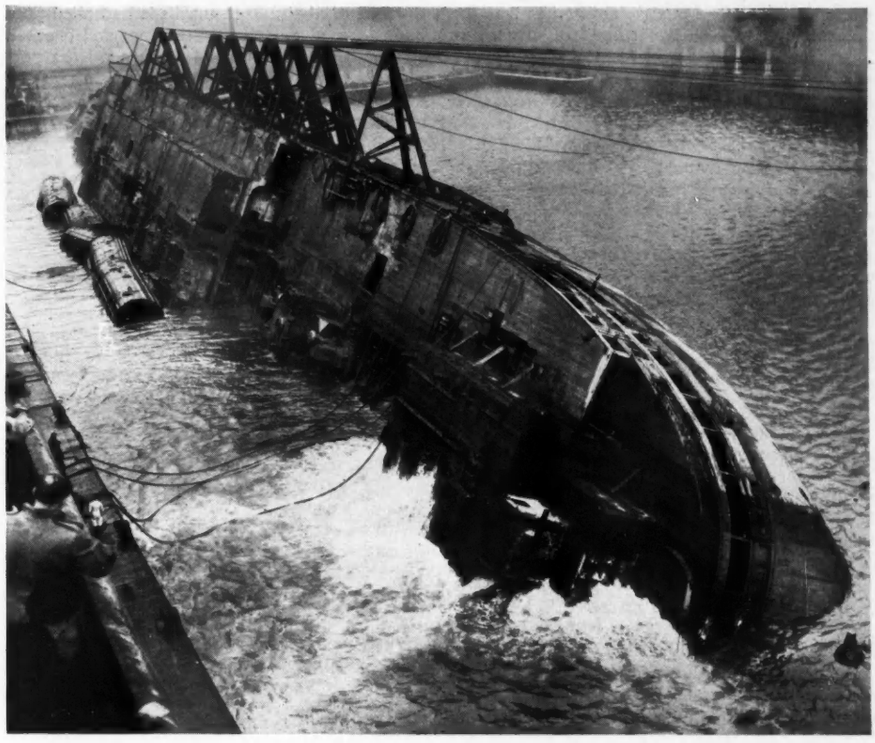
Hydraulic Turbines. The English Electric Co. Ltd., Marconi House, Strand, London, W.C.2, have announced that the English Electric Co. of Canada Ltd., have received an order from the Quebec Hydro-Electric Commission for four hydraulic turbines for the Commission's Lac Casse (River Bersimis) development scheme on the north shore of the St. Lawrence River, some 70 miles north of Forestville down river from Quebec. The Bersimis will be dammed and the water will flow, from an artificial lake, some nine miles through a tunnel to an underground power plant. Ultimately, the station will house eight units. The turbines are designed to develop a rated output of 150,000 b.h.p. at 277 r.p.m., under a net head of 785 ft. Each machine will be capable of developing 175,000 b.h.p. under a maximum head of 875 ft. The basic development and engineering are being done by the English Electric Co. Ltd., in England, while the actual manufacture will be carried out in the Group's John Inglis plant, at Toronto.

Water-Wheel Generators. Metropolitan-Vickers Electrical Export Co. Ltd., Trafford Park, Manchester, 17, have also secured an order from the Quebec Hydro-Electric Commission for four waterwheel generators for the Lac Casse scheme. The rating will be 120 MVA for normal service and 138 MVA for maximum continuous service, the ratings being applicable at any power factor from 0·95 to unity. The first two machines are to be commissioned by the end of 1956.

Wireless Transmitters for B.B.C. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex, have received an order from the British Broadcasting Corporation for the construction of 26 very-high-frequency, frequency-modulated (F.M.) transmitters for sound broadcasting. Delivery will commence within 14 months. The transmitters, comprising 24 of 4½ kW power and two of 10 kW, will form part of the Corporation's plan to provide a powerful reinforcement to the coverage of its present medium and long-wave stations, by the use of V.H.F., F.M. stations. As envisaged, the 4½-kW transmitters will operate in parallel pairs, each pair handling one programme. Thus, six of these transmitters will be used on each three-programme station. The two 10-kW transmitters will be used in parallel at the B.B.C.'s existing V.H.F. station at Wrotham, where there are already two 25-kW Marconi transmitters. Nine of the firm's station monitors have also been ordered by the B.B.C.

The Corporation have also placed an order with Standard Telephones and Cables Ltd, Connaught House, Aldwych, London, W.C.2, for the firm's latest type V.H.F., F.M. sound broadcasting transmitters. The order calls for twelve 10-kW transmitters of type C.F. 4, and twelve 1-kW transmitters of type C.F. 2. In this case also at each station twin transmitters will be used for each programme so that either transmitter can be switched off without interrupting the service.

Gear Units for Water-Turbine Plant. David Brown and Sons (Huddersfield) Ltd., have received an order from Gilbert Gilkes and Gordon Ltd., for two sets of combined helical and bevel increasing gear units, which will be incorporated in water-turbine plant under construction at Tumatumari Falls, British Guiana. The units are designed to transmit 1,100 h.p. continuously at 104/1,000 r.p.m.



The burnt-out and capsized hull of the liner "Empress of Canada" being righted by means of winch ropes and pontoons.

SALVING THE "EMPRESS OF CANADA"

When, on January 25, 1953, the Canadian Pacific liner Empress of Canada capsized on fire in the Gladstone Dock, Liverpool, she heeled over towards the quay and eventually settled with her port side flat on the dock bottom and the funnels crushed against the quay wall. It was not, perhaps, the most awkward position, from the salvage point of view, that the wreck could have assumed—salvage would have been more difficult, probably, if she had heeled away from the quay; but the situation of the vessel, and her size, 582 ft. long, with a gross tonnage of over 20,000, presented the salvage department of the Mersey Docks and Harbour Board with exceptional problems. The first and most important of these, that of righting the vessel, was successfully accomplished on Saturday, March 6, after more than a year of preparatory work.

A picture taken before the operation began, showing pontoons filled with water to assist in righting the vessel.

Under the Act which, in 1857, constituted the Mersey Docks and Harbour Board, the Board are responsible for the removal of wrecks within the port. The work was undertaken, therefore, under the direction of Captain W. R. Colbeck, R.N.R., the Board's marine surveyor and water bailiff, and his assistant, Captain A. G. M. Whitman, together with Mr. Charles Brook, the superintendent of salvage plant, and his assistant, Mr. S. Hickson. Full particulars of the vessel were available from the builders, John Brown and Company, Limited, Clydebank, and from these a skeleton model was constructed in plywood, showing the disposition of the decks, and the internal subdivision. The funnels, masts, and as much as possible of the superstructure were cut away, using portable Quasi-Arc cutting and welding plant; but no attempt was made to remove any of the interior structure or the heavy machinery weights. This would not have been practicable; nor was it possible to seal the various open ports, etc., in the submerged port side of the wreck.

The quay against which the vessel lay was on the north side of the Gladstone No. 1 Branch Dock. The No. 1 Branch and No. 2 Branch Docks open out of the Gladstone Half-Tide Dock, and the system is separated from the Hornby Dock, to the south, by a spur of land which has transit sheds on both sides, with an open space between. In this space a block of mass concrete, amounting to some 4,000 tons, was put down as a foundation for the winches required to haul the vessel upright. The top surface of the foundation was set slightly below ground level so that, when the winches have been removed,

the concrete can be quickly covered in and the space between the sheds restored to normal use.

On the exposed starboard side of the wreck were erected 16 steel tripods, 25 ft. high, constructed by Harland and Wolff, Limited, each with a fairlead at its apex over which to lead the righting hawsers. These were made by British Ropes, Limited, at their Rutherglen factory and were 9 in. in circumference, each containing 366 wires, and having a thimble spliced into each end. At the ship's end, each hawser was led over the fairlead on its tripod and secured to the hull structure. At the other end, the hawsers were attached to six-fold purchases of 3½-in. wire rope, on which the winches hauled. These purchases were supplied by the Whitecross Company, Limited, Warrington.

It had been calculated that each righting hawser would have to apply a pull of about 110 tons, and the deadweight to be moved was about 15,000 tons. No special allowance was made for any suction effect, as the mud in the dock bottom is soft and not notably adhesive. Additional righting moments were applied by means of camels, and by pumping out, with compressed air, a number of compartments on the port side that it had been possible to seal. These compartments, when empty, gave a lifting force of between 4,500 and 5,000 tons.

The camels, most of which were obtained from the Admiralty, were used in two ways. Six of them, filled with water and weighing about 100 tons each, were suspended by wire ropes at the turn of the bilge on the exposed starboard side of the hull. Others were sunk between the wreck and the quay, secured to the hull and the water in them blown out by compressed air, thus adding a combined lifting force of nearly 900 tons. These camels were cut away in succession as the righting of the hull raised them out of the water.

The operating of righting the vessel began shortly after noon on March 6. As soon as the pull of the winches came on the hawsers, the vessel began to roll upward on her port bilge, the angle traversed being indicated on an inclinometer erected on the starboard side. As she turned upward, the ship slid away from the quay for a distance of about 20 ft. until she had piled up a bank of mud on the dock bottom and checked against it. She continued to turn on the port bilge until at an angle of 45 deg., where she balanced, with the hawsers slack. Thereafter, a pull on one hawser only was needed to complete the righting movement. The hull came to rest with a port list of 11 deg.

The ship is not yet afloat, but she is sufficiently far away from the quay to enable it to be used again for berthing ships. Some months will elapse before the Empress of Canada can be towed away from the dock for breaking up, as there is a large accumulation of mud to be removed from the compartments on the port side, and much of the water still in the hull must be pumped out. It is estimated that the salvage operations will have cost about £380,000, of which not more than £50,000 is likely to be recovered by the sale of the ship as scrap.

SCOTTISH INDUSTRIAL DESIGN

Congress and Exhibition at Edinburgh

Following the success of their two previous large-scale undertakings, the "Enterprise Scotland" Exhibition at Edinburgh in 1947, and the "Living Traditions" Exhibition at Edinburgh in 1951, the Council of Industrial Design Scottish Committee have arranged to hold a Scottish Design Congress at the Assembly Rooms, Edinburgh, on Wednesday and Thursday, May 26 and 27, 1954.

Lord Home, Minister of State for Scotland, has agreed to open the congress, which will have as its theme the promotion of design as a high-level responsibility in industry, commerce and the public services. A considerable number of papers will be presented and, although the congress is primarily a Scottish event, the speakers will come from important organisations in many parts of Britain. They will include, among others, Sir Walter Puckey, President of the Institution of Production Engineers, and Sir John Maud, K.C.B.

As a background to the papers and discussions, there will be an exhibition illustrating developments which have taken place in design during recent years.

Further information may be obtained from the secretary to the committee, 95 Bothwell-street, Glasgow, C.2.

H.M. SUBMARINE "EXPLORER"

HYDROGEN-PEROXIDE PROPELLING MACHINERY

The first of a new type of submarine for the Royal Navy, H.M.S. Explorer, was launched on Friday, March 5, from the Barrow shipyard of Messrs. Vickers-Armstrongs Limited. The naming ceremony was performed by Lady Reid Young, wife of Sir James Reid Young, the chairman of Vickers-Armstrongs Limited. For security reasons, practically all technical details of the vessel are being withheld, but it has been stated officially that she is "of a new streamlined type, designed to operate at high underwater speeds," and that her propelling machinery, also being constructed by Vickers-Armstrongs Limited is "of novel design, employing hydrogen peroxide." She has an overall length of 225 ft. 6 in. (178 ft. between perpendiculars) and a beam of 15 ft. 8 in.; which, as the cruising radius will be some thousands of miles, may be taken as an indication of the space that is being saved by the adoption of the new form of propulsion. The previous ("A") class have a length overall of 282 ft. and a beam of 22 ft. 3 in. The Explorer is being fitted with the latest escape arrangements, including the one-man escape chamber and individual escape breathing apparatus of the most up-to-date pattern.

Lieutenant-General Sir Ronald Weeks, K.C.B., chairman of Vickers, Limited, speaking on behalf of the builders at the luncheon which followed the launch, said that the Explorer was the first submarine to be launched for the Royal Navy since 1948. Her performance would be far in advance of that of her predecessors. The Barrow yard, he added, had been building submarines since 1886.

Rear-Admiral G. Barnard, Deputy Chief of the Naval Staff, replying to the toast of "The Guests," said that the Explorer represented the first real test of the very advanced machinery design involving the use of hydrogen peroxide. The basic idea was due to a German, Dr. Helmuth Walther. It was still under development by the German Navy when the war ended. Subsequent development work undertaken in England by Dr. Walther and others had led to the Explorer—very properly so named, he added, for there was still a lot to learn, in a whole series of new fields.

Launch of H.M. Submarine "Explorer," which is to have hydrogen-peroxide propelling machinery and will be capable of high underwater speeds.

BOOK REVIEWS

Heat Transfer by Radiation. By J. H. McGuire. Fire Research Special Report No. 2. Department of Scientific and Industrial Research and Fire Offices' Committee. *H.M. Stationery Office, York House, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

Many practical problems connected with heating and lighting, with furnace design and the spacing between buildings to safeguard against fire risks require a knowledge of the radiative transfer of energy between pairs of surfaces. The radiation intensity from a surface depends on the emissivity of the surface and is proportional to the fourth power of its absolute temperature, while the transfer to a receiving surface depends on the geometrical relationship between radiator and receiving element. The latter is appropriately taken into account by means of a " configuration factor," a number varying from zero to unity representing the ratio of the radiation intensity at the receiving element to that near to the radiator, which is a function only of the solid angle subtended by the radiator at the receiving element.

After discussing the additive property of configuration factors, introducing the concept of equivalent surface and stating the configuration factor cosine law, methods of determining these factors geometrically and by an optical method are described. Expressions for configuration factors relating to the infinite plane and strip, the sphere, the circular disc and rectangle for the general and two special cases, the infinite and finite cylinder (the latter being approximate) are set out. Some of these expressions are lengthy and the numerical tables, placed at the end in an appendix, will materially curtail the computation involved in calculating configuration factors, as is indicated in a worked example.

When the total radiation flux across a receiving surface of finite area is required instead of the intensity at a particular point on it, integrated configuration factors have to be determined and the procedure for obtaining these is illustrated by an example. The calculation of heat transfer between reflecting surfaces generally involves the summation of an infinite series, but a much simpler algebraic method is used to deal with multiple reflections between infinite parallel plane surfaces, two finite non-concave surfaces and between concentric spheres or concentric cylindrical surfaces assuming uniform radiation over both surfaces and diffuse reflections subject to Lambert's cosine law. A list of references completes a report that will be of real service to heating and illuminating engineers.

Simultaneous Linear Equations and the Determination of Eigen Values. Edited by L. J. Paige and Olga Taussky. National Bureau of Standards Applied Mathematics Series 29. *The Superintendent of Documents, U.S. Government Printing Office, Washington* 25, *D.C., U.S.A.* (1·50 dols.)

Under the sponsorship of the National Bureau of Standards in co-operation with the Office of Naval Research, a symposium on the solution of systems of linear equations and the determination of eigen values was held at the National Bureau of Standards Institute for Numerical Analysis at Los Angeles from August 23 to 25, 1951. Various mathematicians were invited to submit reports on selected topics, those on simultaneous linear equations being confined to finite systems and those on the determination of eigen values including discrete and continuous cases together with the determination of bounds for the eigen values. The majority of the reports presented on that occasion are collected together in this volume though there is no report on the round-table discussion that concluded the meeting. The increasing use of high speed automatic digital computing machines made the opportunity thus afforded for active workers in this field to meet and discuss progress particularly timely.

The first paper contains a tentative classification of methods for solving systems of linear equations and is followed by a bibliography listing some 450 titles on numerical matrix methods. The next six papers are devoted to iterative and other machine methods for solving linear equations including a relaxation method capable of solving n equations in n unknowns in precisely n steps together with a discussion on errors in matrix calculations while three subsequent papers deal with matrix inversion and computations involving inverse matrices. The remaining nine papers cover various problems relating to eigen values and eigen functions, including general and variational methods for their approximate and exact computation and new results in the perturbation theory of eigen value problems.

Engineers will find R. A. Frazer's contribution on " Some problems in aerodynamics and structural engineering related to eigen values," of particular interest, outlining, as it does, methods of replacing a continuous system by a finite one chosen in such a way that the two systems have (approximately) the appropriate band of eigen values in common. Illustrations cover aeroplane wing flutter, the vibration frequencies of a string of beads, bending and torsional oscillations of a bridge box structure and some of the many largely unexplored problems of stability of fluid flow.

Hand Tools. Case Study Data on Productivity and Factory Performance. Prepared for the Foreign Operations Administration Productivity and Technical Assistance Division, by the United States Department of Labor. Distributed in Great Britain by the *British Institute of Management, Management House,* 8 *Hill-street, London, W.*1. (5*s.*)

This report is one of a series dealing with individual industries, or with a limited number of products of a particular industry. It covers the manufacture of three different hand tools: a flat file; a monkey wrench, or as it is better known in Great Britain, an adjustable spanner; and an expanding bit for wood boring. The report is not intended to give novel technical information; its object is to provide a means whereby manufacturers in this county can compare their own methods with those used in similar plants in America. The plants surveyed in the report have been chosen because their products are as nearly as possible the same as those of factories on this side of the Atlantic, and direct comparisons of methods and man-hour figures are possible.

Each tool is dealt with in a similar manner. There is an introductory chapter in the form of a general survey of the manufacture of the tool in the United States, and following this, a detailed study of the methods used in two (or in the case of the wrench, three), representative plants. In these chapters the whole process of manufacture, from raw material to finished product, is broken down into individual operations, and a statement of the number of man-hours required for each operation is made. The report shows that the methods employed are orthodox. In the manufacture of files there is, as would be expected, a considerable amount of special machinery, but in the production of bits and wrenches the equipment used is of well-known types. Movement of components from process to process by conveyor or power-truck is practised, and in the assembly of wrenches power-driven tools are mentioned, but there is also a certain amount of hand-work, both on the bench and in material movement. The technological features detailed in the report are, in fact, the same as would be found in a plant in this country engaged on comparable work. The report concludes with a review of labour conditions in the American hand-tool industry, which it is possible to compare with conditions in this country, and a note on adjustments to technological change which does not relate to the hand-tool industry.

The number of manufacturers engaged in the production of the tools mentioned in the report is small in this country, as it is in the United States, and it is therefore inevitable that the report will be of limited interest here. Nevertheless, it is worthy of examination by those whose products are the same as, or even similar to, those studied. The work of comparison between British and the selected American plants is simplified by the inclusion in the report of the questionnaire on which it is based. The questionnaire is detailed, and if the appropriate British figures are filled in, direct comparison of the plants on the same basis becomes possible.

* * *

BRITISH STANDARDS

The following publications have been issued by the British Standards Institution. Copies are available from the Sales Department of the Institution, 2 Park-street, London, W.1, at the price given after each title.

Guide to the Selection of Fits. (7*s.* 6*d.*, post free.)

A new publication, entitled " Guide to the Selection of Fits," is intended as a supplement to B.S. 1916 : Part 1 : 1953, which covers limits and fits for engineering. It provides reliable data in the form of recommended tolerances which can be used for a wide variety of standard applications. The introduction of a new limits and fits system is inevitably a long-term project and many users, faced with the wide choice of fits in Part 1, might feel that a long period of experiment would be necessary before they could decide which tolerances to adopt as standard. Reference to the present publication, B.S. 1916: Part 2: 1953, with its selection of clearance, transition and interference fits for many typical applications, however, should go far to solve this problem and should also minimise the possibility of differing tolerances and allowances being chosen to meet the same design problem. The Guide is fully illustrated and the recommendations it contains are based on the results of investigations carried out with the co-operation of a number of engineering firms and organisations. It is recognised that some requirements are not yet adequately covered and an early revision of the Guide, to include more material, is envisaged. Users are requested to submit to the Director of the Institution their comments, criticisms and constructive suggestions for consideration by the responsible committee.

Power Factor and Permittivity of Insulating Materials. (Determination by Hartshorn and Ward Method) (4*s.*, post free.)

In a new British Standard, B.S.2067, the theory and technique of the Hartshorn and Ward method for determining the power factor and permittivity of insulating materials at radio frequencies are described in detail. The method is suitable for the measurement of power factor and permittivity within a frequency range of 10 kc. per second to 100 Mc. per second, at normal room temperatures. The method is essentially one of capacitance variation in a tuned circuit with a thermionic voltmeter as a detector of resonance. Details are given of the technique to be followed in testing moulded materials, sheet products, tube specimens, and liquids, and drawings are included to illustrate the basic test circuit and some of the equipment involved.

* * *

TRADE PUBLICATIONS

Low-Temperature Welding. We have received from the Suffolk Iron Foundry (1920) Ltd., Sifbronze Works, Stowmarket, Suffolk, a copy of a 28-page booklet (No. 1153 T.P.) which describes in detail low-temperature welding by the Sifbronze process. Data on the welding technique recommended for motor-car repairs, the making of tubular structures and for repairs to cast-iron components and to agricultural machinery are furnished.

Soldering and Brazing Alloys and Techniques. A series of folders dealing with soft soldering, the soft soldering of aluminium, the use of amalgam fusible alloys (for tube bending, tool mounting and the production of foundry patterns), white-metal bearing alloys and their applications and silver soldering and brazing, have been sent to us by Grey and Marten, Ltd., City Lead Works, Southwark Bridge, S.E.1. Much interesting and useful information is given in the folders in simple and concise language.

Degreasing Solution. A leaflet giving particulars of their Gunk D.P. solution – an all-round degreasing and cleansing medium for motor-car parts, oil-saturated floors, factory walls, coachwork and greasy overalls – has been issued by Bennett (Hyde) Ltd., Boston Mills, Hyde, Cheshire.

Conversion of Elongation Data. Stewarts and Lloyds, Limited, Brook House, Upper Brook-street, London, W.1, have issued a pocket-sized Ivorine card on which are given data for the inter-conversion of percentage elongations corresponding to different gauge lengths of steel tensile-test specimens. A table on the card shows directly the percentage elongations on $4\sqrt{A}$ equivalent to given elongations on 2 in. A nomogram enables the conversion to be made for any usual rectangular test-piece.

Nickel-Alloy Spring Materials. A revised edition of their publication "Nickel-Alloy Spring Materials" has been issued by Henry Wiggin & Co. Ltd., Wiggin-street, Birmingham, 16. This presents, in convenient form, data to assist designers to select materials for springs where resistance to corrosion or to high temperatures are of importance, or for use at temperatures in the sub-zero range. The present edition contains data on Nimonic 90.

Heating Boilers. A booklet issued by Bouëllat Engineering, Ltd., 167-168 Millbank, London, S.W.1, describes their range of boilers for hot water or low pressure steam. Outputs range from 750,000 to 5,750,000 B.Th.U. per hour with pressures up to 100 lb. per square inch. They can be used with any type of fuel or method of firing.

Variable-Speed Belt Drive. J. H. Fenner & Co., Ltd., Hull, Yorkshire, have published a brochure describing their new variable-speed belt drive which is primarily designed for spinning-frames. The variable-speed pulley has two grooves and the adjustment operates all four cones so that the belts remain in line. A total variation of 59 per cent. can be obtained. There is a Vernier indicator to show the speed setting and an internal locking mechanism which makes the pulley a solid unit when the speed has been selected.

Earth-Moving Equipment. We have received a number of leaflets from Blaw Knox, Ltd., 94 Brompton-road, London, S.W.3, giving full details of their hydraulically-controlled angle- and bull-dozers, which are attached to David Brown tractors, their Mk. II, double-drum cable-control unit, and their excavators with face-shovel and drag-shovel attachments.

Diesel Engines. Davey, Paxman Co., Ltd., Standard Ironworks, Colchester, have published a booklet entitled "Paxman RPH Diesel Engines for Railway Traction." It gives full particulars of these V-type engines, which can have from 4 to 16 cylinders, and can be fitted with pressure-charging equipment. The smallest engine develops 133 b.h.p. and the largest, which is supercharged, develops 667 b.h.p.

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BOOKS RECEIVED

Technical Reports of the British Electrical and Allied Industries Research Association:

Development of a Specification for a Discharge ("Ozone") Resistance Test for Rubber Insulated Cables. No. F/T180. (7*s.* 6*d.*)

Flameproof Enclosures—Effect of Size and Shape of Enclosure on the Maximum Experimental Safe Gap. By C. E. R. BRUCE. No. G/T289. (6*s.*)

Creep Properties of Steel Utilized in High Pressure and High Temperature Superheater and Steam Pipe Practice. Part III: Revision of Long Time Creep Data for a Carbon Steel Header and a Carbon-Molybdenum Steel Pipe. By R. W. RIDLEY. No. J/T156. (10*s.* 6*d.*)

The Magnitude of the Radio Interference in the Television Band from Ignition of Motor Vehicles. By A. H. BALL and W. NETHERCOT. No. U/T123. (6*s.*)

In Situ Methods of Measuring Soil Moisture Content—A Critical Résumé. By B. A. EASTWELL. No. W/T27. (15*s.*)

Research into the Properties of the Hydrogen-Oxygen Cell. By F. T. BACON. No. Z/T94. (10*s.* 6*d.*)

Offices of the Association, Thorncroft Manor, Dorking-road, Leatherhead, Surrey.

Portuguese West Africa (Angola). By T. C. SHARMAN. Overseas Economic Surveys. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

Industrial Water Resources of Canada. Skeena River Drainage Basin, Vancouver Island, and Coastal Areas of British Columbia, 1949-51. By J. F. J. THOMAS. Water Survey Report No. 5. *The Director, Department of Mines and Technical Surveys, Mines Branch, Industrial Minerals Division, Ottawa, Canada.* (75 cents.)

The Engineering Outlook—11

AGRICULTURAL MACHINERY

WORLD DEMAND REVIVES

IN a world where the population is growing so rapidly that it is in danger of outstripping the available food supplies, it is somewhat of an anomaly that the demand for agricultural machinery should fall. Amid all the triumphs of agricultural technology, it is scarcely credible that it should be left to the primitive Malthusian forces of famine and disease to restore the balance, but a happier solution will require a greatly increased investment in machinery and equipment for raising farm productivity, and for bringing under the plough vast tracts of hitherto uncultivated land. The fall in the demand for agricultural machinery in 1953 was due mainly to an exceptional factor, namely, the reduction in farmers' income which followed the fall in commodity prices at the conclusion of the Korean war. Some recovery is already evident, but so long as international action to provide the farmers in backward countries with adequate capital is weak and faltering, the large potential demand will never be realised.

The Colombo plan and the American Point Four Programme for world development are promising beginnings, but much more will be required, particularly from the United States, which is by far the largest creditor nation of the world. A deep and protracted slump in the United States could have tragic consequences if, besides depressing world commodity prices, it reduced the flow of American foreign lending; it is to be hoped, therefore, that the Government's economic advisers are right in their diagnosis that the present fall in economic activity is due primarily to adjustment of stocks.

The problem of raising agricultural output is not simply one of increasing mechanisation in backward territories; even in the most highly-developed countries, which are still the largest markets for farm machinery, there tends to be a very wide gulf in productivity between the most efficient and the least efficient farms. At one end of the scale, mechanisation has been carried in some cases to the point of over-capitalisation; at the other, small farmers often lack the means and ability to improve their methods. Consequently, a higher demand for agricultural machinery may require the solution of some difficult human as well as financial problems.

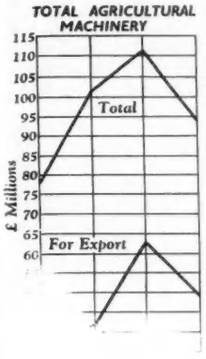
PROSPECTS FOR HOME SALES

The interests of the British agricultural-machinery industry are fairly evenly divided between home and abroad. The general fall in output for almost all types of equipment in 1953, illustrated in the accompanying twelve graphs on the following pages, was due largely to the decline in export sales. Exports of tractors fell by £5·2 millions to £37·2 millions, and exports of other types of agricultural machinery, again by £5·2 millions, to £12·5 millions; these figures are amplified in Table I below, and Table II and III on page 364, taken from the *Trade and Navigation Accounts*. While, over the whole range, the exports of agricultural machinery thus fell by about a quarter, home sales were down by only about 6 per cent. The fall in home sales is particularly discouraging, however, because British farmers enjoy the protection of guaranteed prices and did not experience the drop in income which affected farmers elsewhere. In the United States, farm income fell by 2,400 million dols. to 12,400 million dols. in 1953 as a result of a drop in agricultural prices of 9 per cent., but the index of agricultural prices in the United Kingdom rose by 4 per cent. The British Government, moreover, are committed to the maintenance of a system of guaranteed prices in furtherance of the objective of raising output to 60 per cent. above pre-war by 1956. Farmers are not entirely happy about the Government solution of what Mr. R. A. Butler has described as "the most difficult problem in modern times," that of securing choice and plenty for consumers while providing stability for agricultural producers.

The new marketing schemes for the various agricultural products vary considerably in detail, but they generally combine free-market sales with

TABLE I.—UNITED KINGDOM: EXPORTS OF AGRICULTURAL TRACTORS, BY COUNTRY OF DESTINATION

	Quantities (Numbers)			Value (£1,000)		
	1951	1952	1953	1951	1952	1953
Union of South Africa	12,177	3,975	5,925	4,269	1,515	2,336
Southern Rhodesia	1,428	564	502	604	272	207
British East Africa	1,017	1,045	544	487	550	259
India	5,465	912	964	2,149	414	364
Australia	21,515	13,364	14,670	7,111	4,307	4,933
New Zealand	7,006	6,706	7,335	2,525	2,450	2,762
Canada	6,939	6,517	3,851	2,226	2,412	1,650
Other Commonwealth Countries	2,090	2,814	2,361	834	1,264	1,115
Irish Republic	3,419	3,062	3,730	1,107	1,169	1,555
Finland	3,366	5,407	1,829	1,255	2,167	804
Sweden	8,130	10,850	11,150	2,899	4,422	4,315
Norway	3,154	3,969	3,555	1,005	1,323	1,298
Denmark	7,436	11,121	8,399	2,448	4,086	3,166
Netherlands	2,240	2,508	1,903	780	952	795
Belgium	1,464	2,009	1,783	551	838	711
France	4,096	4,525	6,042	1,618	1,947	2,332
Spain	1,313	942	1,170	646	562	724
Italy	1,487	3,795	4,464	638	1,743	2,104
Greece	373	388	205	207	194	99
Turkey	8,067	8,257	796	3,822	4,780	590
Algeria	725	986	629	320	488	317
Egypt	2,309	199	383	712	69	138
United States of America	1,088	2,129	3,940	127	272	797
Cuba	596	386	368	249	166	177
Brazil	1,674	1,420	529	788	622	243
Uruguay	551	1,324	384	241	616	220
Argentine Republic	99	208	624	40	161	446
Other countries	3,435	5,564	5,646	1,474	2,570	2,713
Total	112,659	104,946	93,681	41,132	42,331	37,170



Total production of agricultural machinery in the United Kingdom during the last four years. (The years are taken to end on September 30.) The decline in agricultural prices and farmers' incomes which began in the second half of 1952 was responsible for the fall in sales during 1953. There was, however, an improvement after October, 1953.

a system of deficiency payments. These are designed to give an incentive to efficient production, but in times of falling world prices large subsidies may be necessary to maintain minimum prices. Farmers are naturally worried lest the increasing burden on the taxpayer should jeopardise the whole system of guarantees. For them, trade protection would be preferable in many ways to the open market, since the high cost of home-produced commodities would be less apparent to the taxpayer. The advantages of the open market to the consumer are obvious, but the free-trade argument cannot be pressed too far. It cannot be assumed that the future trend of imported raw material prices will be downwards indefinitely.

Increasing competition from the industrial nations, all anxious, like the United Kingdom, to expand their exports of finished products, as well as the pressure of expanding population, may drive up world commodity prices. If so, of course, British agriculture will benefit automatically, and eventually the need for protection or subsidies will disappear. Apart from any strategic reasons, therefore, there is a strong case for continuing to subsidise British agriculture as a temporary measure if, thereby, farmers are enabled to improve their efficiency and keep down prices. Food subsidies, which are at present at the rate of £300 millions per annum, payable mainly to home agriculture, are already onerous enough, however, and cannot be defended unless they are translated in large part into an effective demand for agricultural machinery.

THE PROBLEM OF MECHANISING SMALL FARMS

The British agricultural industry is one of the most highly mechanised in the world, and productivity has been rising; the output per man is now 30 per cent. higher than in 1938, which compares well with the progress in manufacturing industry. Much remains to be done, however, for the differences in efficiency between farms are very considerable. In milk production, for example, costs per gallon for the season June, 1949, to May, 1950, ranged from 1s. 1d. to 3s. 11d. The norm, which covered nearly half the sample taken, was from 1s. 8d. to 2s. 2d. per gallon. Unfortunately, while the scope for further mechanisation on many of the larger farms is limited, the financial resources of the smaller are often inadequate. Of the 536,000 agricultural holdings in the United Kingdom, only 15,313 exceed 300 acres, and 356,000 are under 50 acres. If small-holdings of up to 15 acres are excluded, there still remain 135,000 farms of less than 50 acres. These 135,000 small farms depend mainly on family labour, and occupy in total a much smaller acreage than the 15,313 large farms, which together account for about one-fifth of the acreage of crops and grass in the country.

The small farmers have been the hardest hit by the return to free marketing. The decontrol of feeding stuffs and the abolition of the subsidy on them, means, since the small farmers are unable to grow their own, that they will require higher prices for their produce in order to maintain their incomes. Guaranteed prices, however, are being fixed just high enough to maintain the level of total farm income in the United Kingdom. This certainly puts a premium on efficient production, for the efficient producers will receive an increasing proportion of the total, but it means hardship for many small farmers; moreover, the present system of tax reliefs tends to make capital investment more difficult on the small than on the large farm.

Efficient production demands an extensive outlay on fixed as well as working capital, and although the former is usually the responsibility of the landlord (for 60 per cent. of British farmers rent their holdings) he may not find it easy to provide the finance. The landlord with ample funds can have these supplemented by a public grant if he invests in, say, a farm cottage, and he will also qualify for generous tax relief. None of these benefits is available to the landlord who cannot afford the initial outlay.

The gradual elimination of the small farmer may be defended as necessary for further agricultural progress. It is certainly true that efficiency would be increased if small farmers amalgamated, or could be induced to sell out to larger farmers. A reduction in their incomes might not necessarily have this effect, however; by their acceptance of a low standard of living and long working hours, the small farmers might simply become a new depressed class, and, far from ensuring the most productive use of agricultural resources, this might slow down the present rate of progress. Whatever the solution, it is not an easy one; but it is certainly true that British agriculture cannot afford not to mechanise. To some extent, mechanisation might be encouraged if land valuations were revised and rents so related to the earning potential of farms as to encourage the more effective use of land. While, however, Government policy fails to take into account the problem of the small farm, the recovery in home sales of agricultural machinery, which began in the second half of 1953, may not be permanent.

One welcome development is the removal of the restrictions on the capital expenditure which the British Electricity Authority is permitted to undertake on rural electrification. High productivity in Denmark, to no small extent, is due to the plentiful electricity supply. Apart from the savings in labour costs, fuel and operating costs can be greatly reduced by the use of electric power for milking machines, pumps, steam-raising, etc. As yet, less than half of the agricultural holdings in the United Kingdom enjoy the advantages of mains electricity.

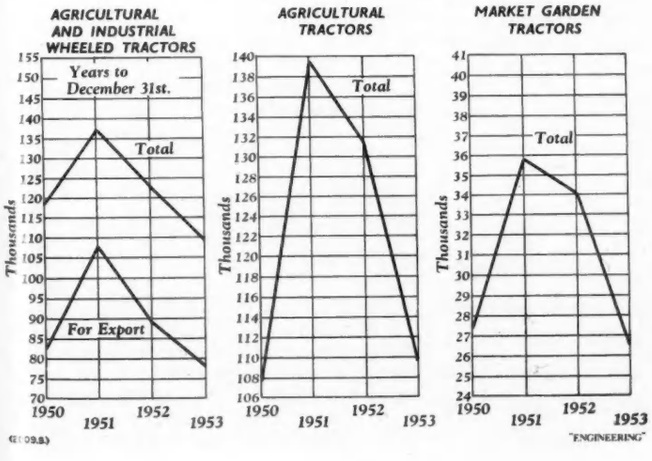
SALES PROSPECTS IN UNDER-DEVELOPED COUNTRIES

In the backward countries, the human and physical problems which delay the progress of mechanisation are more pronounced than in those more highly developed. In India, where the Government policy under the Five Year Plan of increasing investment in manufacturing industry and in agriculture is straining the country's financial resources to the limit, farm mechanisation is meeting considerable opposition. One provincial Minister of State is reported to have said that tractors in America have made about 60 per cent. of the fertile land barren, and another that, because mechanisation had failed in India, there must be something wrong with it. Nevertheless, greatly increased food supplies will be required to meet the needs of the rapidly expanding population, and, since the Indians can ill-afford to increase their imports, these additional supplies will have to come from home sources.

Under the Five Year Plan, which ends in 1956, agriculture, irrigation, and combined irrigation and power projects account for 38·5 per cent. of the total planned investment of £1,554 millions. By the end of March, 1954, £750 millions will have been spent, and already considerable progress has been made with projects for irrigating 9 million acres and improving 7 million more. Much marginal land has been claimed by deep ploughing, but progress is limited by the small number of tractors available. It is estimated that there are only about 15,000 in India, or only about one per 21,000 acres.

Imports from the United Kingdom have not exceeded 1,000 in each of the past two years, but the prospects are improving. Ferguson tractors are now being assembled in India, and the first consignment of "knocked down" David Brown tractors for assembly in Bombay was despatched at the beginning of October. Mahindra and Mahindra, Limited, who have been appointed sole concessionaires, plan to open another assembly plant in Calcutta, and hope eventually to handle the complete range of David Brown four-wheeled machines and two-crawler tractors.

Hitherto, the Latin-American markets have not been among the most promising for British agricultural machinery, and in 1953 there was, in many cases, a further fall in the already low level of sales. These markets have been very largely the preserve of United States manufacturers. United States loans, made under the Point Four Programme, amount to over 100 million dols., and United States manufacturers have also had the advantage of long-established business con-



Agricultural and horticultural tractors made in the United Kingdom during the past four years. The figures are for years ended September 30, except as noted for the "Agricultural and Industrial Wheeled Tractors" where the years ended on December 31.

nections in Latin America. In consequence, they supplied 111,000 tractors between 1948 and 1952, whereas British manufacturers supplied only 26,500. The dollar shortage in many Latin-American countries is now, however, even more acute than the sterling shortage, and, even if dollar credits are made available on a larger scale, the Latin-American Governments are likely to have to turn increasingly to Europe if they are to carry out their programmes for agricultural development. Most of them make generous credit available to farmers for the purchase of agricultural equipment and give assistance in other ways, but the number of tractors in use still probably does not greatly exceed 200,000, which is only one per 2,400 acres, compared with one for every 430 acres in Europe.

The urgency of the situation is evident from the decision of the Argentine Government, announced in July, to grant import licences for tractors and agricultural machinery to a value of £24 millions. It has been stipulated that overseas payments will be by instalments, but the strain on the balance of payments will still be quite considerable. Orders have been placed in France for 1,300 tractors, valued at about £2 millions, and import licences amounting to £2·5 millions have been granted for other types of agricultural machinery. British manufacturers have been sufficiently impressed by the market potential in Argentina to make plans to manufacture tractors there. The David Brown Group are preparing to set up a plant, which at first will do mainly assembly work, but will eventually undertake the complete manufacture of tractors. Mr. David Brown, head of the Group, has said that President Peron wants 100,000 tractors, costing about £50 millions, immediately, and that afterwards there will be orders for about 20,000 a year.

British manufacturers are thus in a strong position to develop the Argentinian market, but they will still have to counter stiff competition from Europe as well as the United States. The Germans are already manufacturing several engineering products, including Diesel engines, in Argentina, and are reported to be planning to increase their investments in South America. German exports of tractors to South American markets, which were negligible until 1949, rose to nearly 4,000 in 1952.

British agricultural machinery makers are already manufacturing and assembling their products in many overseas markets. For example, Ferguson implements are being made under contract in France, India, South Africa, Spain and Sweden, and tractors are being assembled in France and in India. The French factory, which has now been in operation for some months, will eventually undertake the manufacture of the complete tractor. A recent development is the proposal of the Ford Motor Company to establish a plant at Barcelona. The Spanish Government published a decree in October which requires them to achieve an output of 3,000 tractors a year, by the fifth year of operation from the plant, which is due to be completed by the early months of 1956. Imports of components and parts from Dagenham will be permitted for the first four years.

TABLE II.—United Kingdom: Exports of Agricultural Machinery Other than Tractors, by Countries of Destination

	Quantities (Cwt.)			Value (£1,000)		
	1951	1952	1953	1951	1952	1953
Union of South Africa	92,004	77 328	51,804	900	839	638
British East Africa	32,150	34,635	30,490	382	482	412
India	77,655	37,224	9,555	768	460	122
Australia	200,001	191,170	125,632	2,532	2,716	1,953
New Zealand	70,585	92,468	67,397	799	1,291	948
Other Commonwealth Countries	82,183	97,997	80,836	1,016	1,422	1,113
Irish Republic	116,998	102,427	119,844	1,060	1,038	1,239
Finland	29,069	62,184	6,704	381	963	119
Sweden	31,444	31,223	16,495	346	427	290
Norway	15,545	16,246	6,774	186	250	133
Denmark	42,292	40,211	20,996	456	504	323
Netherlands	37,339	26,612	20,423	329	231	212
France	63,412	76,951	68,175	915	1,270	1,216
Turkey	85,047	203,877	40,790	1,123	2,707	818
Algeria	14,774	11,029	7,854	189	183	124
Egypt	21,725	11,754	7,065	178	103	58
Brazil	26,749	17,333	8,656	342	333	72
Uruguay	10,386	13,393	10,695	95	130	139
Argentine Republic	14,903	10,965	2,399	152	110	45
Other countries	140,697	176,655	180,883	1,613	2,265	2,524
Total	1,204,958	1,331,682	883,467	13,762	17,725	12,498

TABLE III.—United Kingdom: Exports of Agricultural Machinery

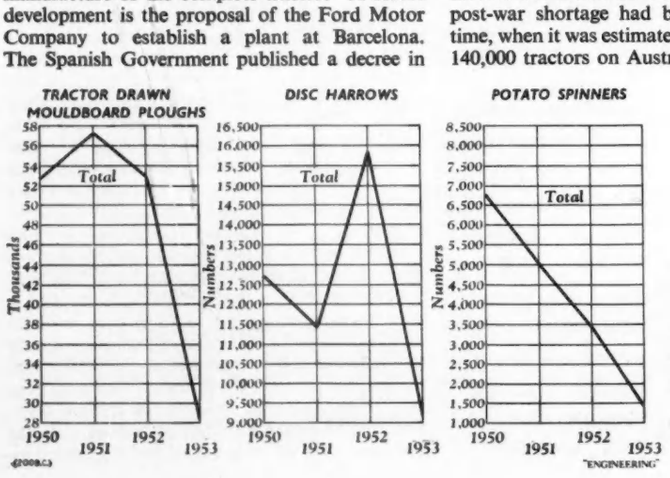
	Quantities (Cwt.)			Value (£1,000)		
	1951	1952	1953	1951	1952	1953
Types other than tractors:						
For preparing and cultivating the soil:—						
Ploughs	354,012	360,670	183,097	3,079	3,376	1,783
Other sorts	—	370,680	236,253	—	4,000	2,668
For harvesting, threshing and sorting :—						
Hay and grass mowers (including morning attachments to tractors) other than rotary blade type	69,524	75,146	50,433	920	1,114	824
Reapers, binders and threshers	24,177	22,846	7,802	247	265	89
Combine harvester-threshers	135,684	204,211	153,451	2,147	4,016	3,196
Other	—	165,902	162,477	—	2,418	2,334
Other descriptions:—						
Sheep shearers and clipping machines	5,593	6,611	3,527	282	416	209
Other	615,968	125,616	86,427	7,087	2,120	1,395
Total	1,204,958	1,331,682	883,467	13,762	17,725	12,498
Tractors	112,659	104,946	93,681	41,132	42,331	37,170
Grand Total	1,317,617	1,436,628	977,148	54,894	60,056	49,668

HOW LARGE IS THE TRACTOR MARKET?

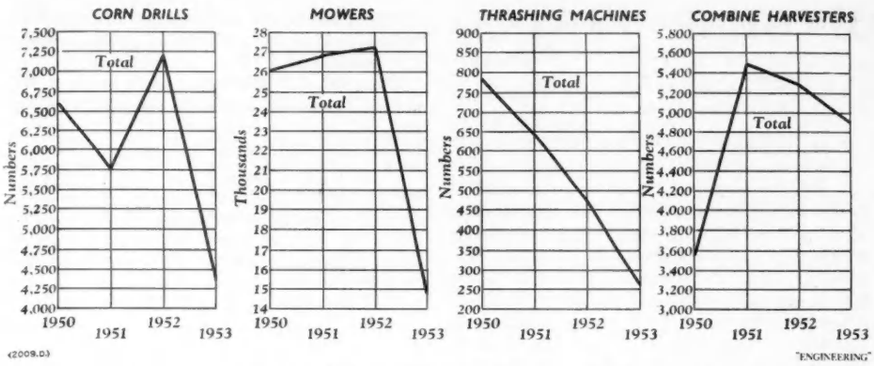
The Commonwealth markets are still among the largest for British manufacturers of agricultural machinery, though their relative importance is tending to diminish. Whereas in 1951 they accounted for just under half of the British exports of tractors, they accounted for less than a third in 1952, and not much more than a third in 1953. There is hope of some increase in 1954. Better economic conditions in Australia, the largest market, resulted in some improvement, but a recovery to the level of 1951, when 21,515 British tractors were sold, is unlikely. The fall in sales in 1952 coincided with a drop in agricultural income and increased credit restrictions, but the post-war shortage had been overcome by that time, when it was estimated that there were nearly 140,000 tractors on Australian farms. Some of the improvement in British exports in 1953 was attributable to the liquidation of the large stocks of tractors in dealers' hands. These had begun to accumulate as early as the closing months of 1951, and by August, 1952, it was estimated that about 10,000 new tractors were in stock.

The more highly-developed countries at present account for a high proportion of British exports of agricultural machinery. The success of British tractors in Scandinavia has been particularly striking. Sweden, the second largest overseas market in 1953, has taken over 30,000 British tractors since 1951, and Denmark nearly 27,000. Since there were only about 8,000 tractors on Danish farms in 1950, this is truly remarkable. The Scandinavian countries have obviously solved the problem of mechanising the small farms and have found British lightweight tractors particularly suitable for their requirements. Nevertheless, purchases of tractors cannot be expected to continue indefinitely at such a high level.

There is, of course, no fixed saturation point for tractors, for the demand can be influenced by many factors. Nevertheless, the limits to their profitable employment under any given set of conditions are usually fairly clear. In Southern Rhodesia, for example, the Department of Agriculture consider that one tractor per 250 to 300 acres is adequate, and, as is shown by a report on the market by the Special Register Service of the Board of Trade, there is little scope for additional sales in that market to deal with existing acreage as at present farmed. Tractor sales will increase, therefore, only as new land is brought into cultivation. This is probably true of many important markets, particularly in the Commonwealth, so that henceforth it will require a much greater capital outlay on agricultural development than hitherto to support a given volume of tractor sales. Since the investment resources of the Commonwealth are



Mouldboard ploughs, disc harrows and potato spinners made in the United Kingdom since 1950, for years ended September 30.



Harvesting machinery made in the United Kingdom during the past four years, for years ended on September 30.

limited, there can be no easy optimism about the future level of sales.

Various surveys which have been made of the demand for tractors have tended to base their estimates upon the number of tractors desirable rather than upon the number which it is practical for a world, hungry for capital, to acquire. The Industry and Materials Division of the United Nations Economic Committee for Europe, for example, have said that it is desirable that the world should be using 14 million tractors by 1956, but even the objective of 10·8 millions, which they consider more practicable, seems hardly likely to be achieved. It would mean an increase of 76 per cent. over the number in use, and would strain greatly not only the capacity of the world to buy, but also that of the industry to supply them. Certainly, there is no shortage of tractor-building capacity at present, but a large increase in demand would fall most heavily on relatively few manufacturers. Farmers are becoming increasingly selective in their purchases, and only tractors with a high performance in relation to initial and running costs can be expected to sell.

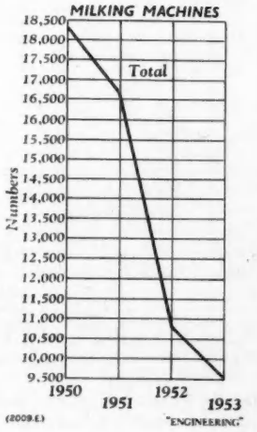
HIGH PRESTIGE OF BRITISH EQUIPMENT

It speaks well for the quality of British tractors that they have been selling well in the United States. An American commentator has stated that importing tractors into the United States is hardly more common than importing bourbon whisky into Kentucky, but Ferguson tractors have been imported, and more recently the Ford Motor Company began to ship Diesel tractors. The tractors built at Dagenham can be offered in the United States for 2,600 dols., which is substantially less than the price of comparable models built in the United States. In the last four months of 1953, it was planned to despatch tractors to the value of about 3 million dols. and the British Ford Motor Company have estimated that it may be possible to export six times as many in 1954. The market for agricultural machinery in the United States, however, has been deteriorating. The trend of sales has been fairly steadily downwards since June, 1952. Certainly, expenditure on agricultural equipment, at 1,600 million dols. in 1953, was still only one-fifth lower than in the record year 1952, but stocks have been piling up, and the outlook for 1954 is far from bright. Nevertheless, the market remains receptive to new products. The Ford Motor Company of the United States, who introduced a new tractor of their own, a cotton harvester, and some other new equipment, succeeded in increasing their sales in the first half of 1953, against the general downward trend.

The progress made by British manufacturers with Diesel power for tractors is of some importance in the fight for world markets. The price of the Diesel-engined Fordson tractor was cut by £40 in August, and the Ford Motor Company claim that it offers the lowest-priced Diesel power on earth. The David Brown Group exhibited at the Smithfield show in December a new Diesel version of their light tractor, powered by vaporising oil, introduced earlier in the year. This has a basic price of £587, and is claimed to be the most economical tractor yet made. A new Diesel crawler tractor is the BTD-6, of 31·3 drawbar h.p., manufactured by the International Harvester Company at Doncaster. The works there are being extended in accordance with a programme financed by a loan of £10 millions raised from British investors, and 2·8 million dols. invested by the American company. Morris Motors, Limited, have also been reorganising their plant layout to achieve higher output of the Nuffield Universal tractor.

REORGANISATION AND NEW DEVELOPMENTS

The amalgamation of the Massey-Harris Company and Harry Ferguson, Limited, should lead to important production and distribution economies. The Massey-Harris Company have so far made only a Diesel tractor of 42 brake horse-power in the United Kingdom; the Ferguson range of lightweight tractors fitted with petrol, Diesel, vaporising or paraffin oil engines is, therefore, complementary. The success of these tractors, which account for about 60 per cent. of the total output of wheeled tractors in the United Kingdom, has been outstanding, both at home and overseas, but the strong Massey-Harris international organisation should greatly assist export sales, particularly in North and South America. The Massey-Harris Company own 14 factories, with a total area of 6·6 million sq. ft. Six are in Canada, three in the United States, three in the United Kingdom and two in Germany. The merger seems to have commended itself to both companies, partly because of the danger of excess capacity which threatens the agricultural machinery industry. The long-term prosperity of the industry is not in doubt; the numbers of producers is unduly large in present conditions, but this will resolve itself as the demand in a more selective market becomes concentrated on the more successful types of equipment.



Numbers of milking machines made in the United Kingdom since 1950, for years ended September 30.

Mr. Harry Ferguson, who is chairman of the new company, will concentrate on design and development. In a statement in August he referred to ten years of secret development work, the results of which should greatly assist agricultural productivity. The prototype of a new tractor of 50 brake horse-power, has already been tested in dealing with gale-blown timber in Scotland, and will be marketed in 1954. Even more interesting is the announcement of a small combine harvester of "revolutionary" design. Harvesting is still a most serious problem and a light, manoeuvrable machine of this type will be a great boon.

The production of more conventional combine harvesters, for which the Massey-Harris Company have already established a sound reputation, continued at a high level in 1953. Although the output for the year was below that of 1952, largely because of a fall of 20 per cent. in exports, home sales for the 1953 harvest were at a very high level, and the output in the third quarter of 1953 was well above that of the third quarter of 1952. In general, the high cost of farm labour has created a demand for mechanical handling equipment, pick-up balers, automatic harvesters, etc., which will not quickly subside, and while British agricultural engineers have the ingenuity to devise new cost-saving equipment, they will have no difficulty in finding a market.

The evolution of a successful potato harvester has presented particularly difficult problems, but a new machine now being produced by the Catchpole Engineering Company has overcome most of them. The separation of stones and clods from the potatoes, which on most harvesters has had to be done manually, is carried out automatically by a method known as aqueous suspension. "Rotavation," the system of cultivation developed by Rotary Hoes, Limited, has gained rapid popularity with farmers and market gardeners. The company have expanded their labour force from 400 in 1946 to about 1,100. Among their more recent products is a new tractor, the Platypus, which is particularly suitable for work in row crops such as hops, raspberries, sugar cane, coffee, etc. Rotary Hoes, Limited, who are the first manufacturers to make a special study of prime movers for bog work, recently tested the Platypus 30 or Bogmaster in Galway. A substantial order has already been placed by the Irish Sugar Company.

The demand for market-garden equipment, as for other agricultural machinery, improved somewhat in the closing months of 1953. Market gardeners have not enjoyed the advantages of guaranteed prices, and consequently many of them have suffered a severe reduction in income in the past few years. The decision to give them some protection by restricting imports of certain market-garden products may help to give them sufficient sense of security to increase the capital outlay on their holdings. One of the most important objectives of British agricultural policy must be to encourage mechanisation. If this is not realised, the huge sums at present being paid out as agricultural subsidies will have been wasted. The problem of mechanising the small farm is being solved in Scandinavia; it is capable of solution in the United Kingdom. British agricultural-machinery manufacturers have the ability and resources to provide all the necessary equipment and, with a healthy home market behind them, they should be able to increase further their share of the world trade.

THE EFFICIENCY OF GEAR TRAINS

FORWARD AND REVERSE VALUES

By H. Clausen, B.SC.(ENG.)

It is sometimes stated that a worm gear becomes irreversible, i.e., its efficiency becomes zero, or even negative, when it is driven in the reverse direction, when the normal efficiency is 50 per cent. or below. This is only a half-truth, and only applies if the gear ratio is high. A pair of equal diameter 45-deg. skew gears – which is, after all, only a special case of a 1 : 1 worm gear – will have the same efficiency both ways whichever member is the driving member, as there is no difference between them. On the other hand, a pair of 1 : 1 skew gears, the diameter ratio of which differs substantially from 1 : 1, will have different efficiencies when working in the two directions.

The difference in efficiency of gear trains when driving from either end varies, among other things, with the gear ratio. Any ordinary spur-gear train may, if the overall gear ratio is high enough, be completely non-reversible for back driving if the efficiencies when driven forward are low enough. The following notes are an elementary analysis of some aspects of this effect.

In most engineering problems, gear trains, whether gearing up or down, usually only drive in one direction. The factors described, though of little importance in the normal gear trains, which are usually geared down in speed, have a major effect in inverted gear trains where speeds increase from the driving point, as efficiencies tend to be lower in this direction.

With the increase in use of servo-gears, particularly for remote power control of directors, mountings, or radar aerials, these factors have become of greater importance. The satisfactory handling of heavy inertia loads by servo-gears involves the efficiency of the gear trains in both directions, in dealing with the energy transfer from servo-motor to load and vice versa, which accompanies changes of speed of the driven member.

A normal train of spur gearing is liable to have quite different efficiencies in the two directions of drive, depending on the gear ratio.

The diagram, Fig. 1, herewith, shows such a gear train, reduced to its simplest terms of two pulley wheels mounted on a common shaft, the radius of the smaller one being taken as unity and the radius of the larger one being K, this being the overall gear ratio. Cords round these two pulleys support weights of w at the larger radius and W at the smaller radius, these representing input or output forces according to the direction of drive.

The shaft is supported in plain bearings of radius R and the total load on these bearings will, of course, be $w + W$. The resultant frictional torque when the gear is moving is $(W + w)\,R\,\mu$, μ being the coefficient of friction. μ is equal to tan β, where β is the friction angle; and the friction torque may be expressed as $(W + w)\,r$, where r is the radius of the friction circle, equal to R tan β. This is possibly over-simplifying the problem. The driving and driven loads may each be carried separately, by separate bearings of different friction-circle diameters, but the reduction of all the gear-tooth and bearing friction effects of a gear train to one single equivalent friction circle appears logical in an elementary approximate treatment.

Given η_1, the efficiency driving forwards and the gear ratio K, it is possible to work out r, the radius of the friction circle. From this, we can work out η_2, the efficiency when driving backwards, and so derive η_2 as a function of η_1 and K. The working is given in the next paragraph and the results are plotted out in Fig. 4, herewith, which shows the relationship between the efficiencies in the two directions, as dependent on the overall gear ratio.

In gearing down, and driving forwards, the efficiency $= \eta_1$. Input = output + friction losses, so, for one radian rotation (Fig. 1)

$$K = K\,\eta_1 + (1 + K\,\eta_1)\,r,$$

$$r = \frac{K - K\,\eta_1}{1 + K\,\eta_1},$$

$$= \frac{1 - \eta_1}{\eta_1 + \frac{1}{K}}.$$

In gearing up and driving backwards (Fig. 2), input = output + losses, and the efficiency $= \eta_2$.

$$K = K\,\eta_2 + (K + \eta_2)\,r,$$

$$= K\,\eta_2 + Kr + r\,\eta_2,$$

$$\eta_2 = \frac{K(1 - r)}{K + r},$$

$$= \frac{K\left(1 - \dfrac{1 - \eta_1}{\eta_1 + \frac{1}{K}}\right)}{K + \dfrac{1 - \eta_1}{\eta_1 + \frac{1}{K}}},$$

$$\eta_2 = \frac{K\,\eta_1 + 1 - K + K\,\eta_1}{K\,\eta_1 + 1 + 1 + \eta_1},$$

$$= \frac{K(2\eta_1 - 1) + 1}{\eta_1(K - 1) + 2}.$$

As an example, with a high gear ratio (anything over 50 : 1), if the efficiency when gearing down is 80 per cent., the efficiency when driving in the reverse direction will be about 75 per cent. If the efficiency when gearing down is 60 per cent., the efficiency in the opposite direction will be about 33 per cent. A negative efficiency indicates that the gear is non-reversible, and that a proportionate torque on the driven side, in the same direction as that on the driving side, is necessary to allow motion to take place.

For an overall gear ratio of 1 : 1, the efficiencies are the same in the two directions, and the intermediate lines show their relationships for different gear ratios. It will be noted that above, say, 20 : 1 overall ratio, there is practically no change in the relationships between the two efficiencies, and, if the forward efficiency is high, the backward efficiency will be nearly the same.

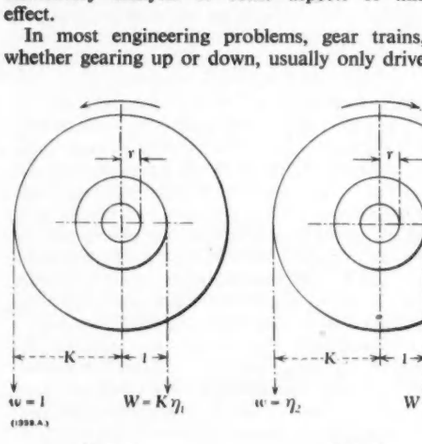


Fig. 1.

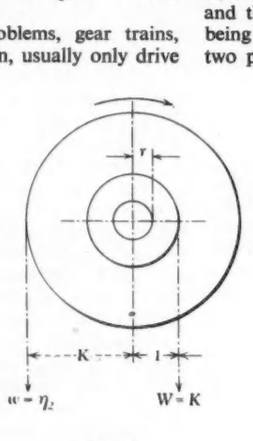


Fig. 2.

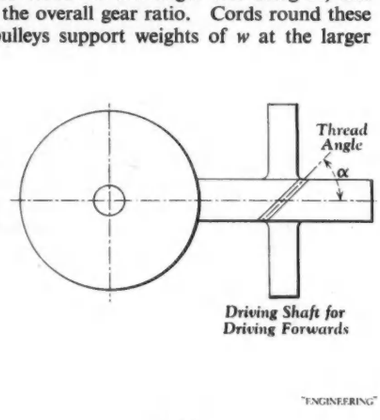


Fig. 3.

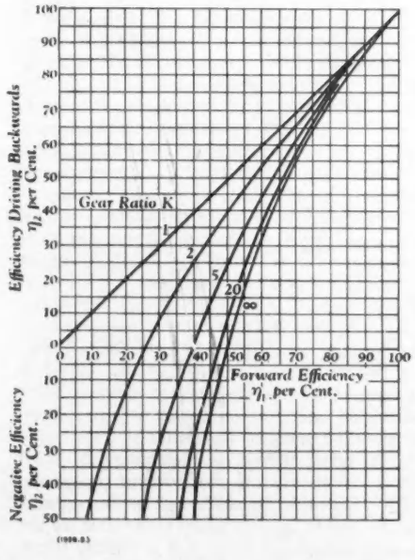


Fig. 4 Spur-gear trains: forward and reverse efficiencies as functions of the gear ratio.

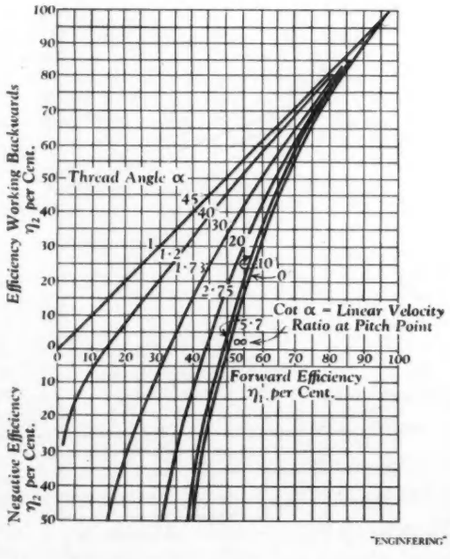


Fig. 5 Skew and worm gears: forward and reverse efficiencies as functions of the thread angle.

In the case of the 1 : 1 ratio, this might be either a series of wheels of equal diameter meshing with one another, or any other symmetrical arrangement of large and small pinions meshing with one another so that there is no distinction as to which end of the gear train is which.

If the overall gear ratio is 1 : 1, and a train is completely symmetrical, the efficiencies will be the same in both directions; but any lack of symmetry in the gear train will produce different efficiencies in the two directions.

To be definitely non-reversible, a gear train should have a definite negative reversed efficiency. The friction coefficient is liable to variation, and small changes may swing the reverse efficiency from negative to positive. Similarly, to secure reversibility, the forward efficiency must be well above the limiting figure.

Fig. 3, opposite, represents the case of skew and worm gears; though, in this case, the treatment does not include any bearing friction and so is only approximate. In the forward direction, $\eta = \frac{\tan \alpha}{\tan (\alpha + \beta)}$; backward, $\eta_2 = \frac{\tan (\alpha - \beta)}{\tan \alpha}$. The angle α is that of the thread, and tan β is the coefficient of friction.

Fig. 5, opposite, shows the corresponding relationship between the efficiencies for the two directions of driving for worm and skew gears, derived from the same familiar formula for the efficiency of a screw thread. The two sets of curves appear to coincide, with a relationship of $K = \cot^2\alpha$, α being the thread angle on the driving side.

Tests of efficiency of worm and spur gears have given figures which are in reasonable agreement with these curves, when allowance is made for the difficulties in getting accurate efficiency figures due to variation in the friction coefficient, bearing friction, etc.

SOME UNSOLVED TECHNICAL PROBLEMS

Industry frequently requires, for the development of its technical processes, information not already provided in the due course of scientific research; and, in order to bring such requirements to the notice of bodies able to deal with them and to stimulate the study of those materials and properties about which knowledge is needed, a booklet, entitled *Some Unsolved Problems*, has been published by the American Society for Testing Materials. Foremost among the objects of the Society are " the promotion of knowledge of the materials of engineering and the standardisation of specifications and the methods of testing " ; and as a contribution to these aims there has been assembled the list of unsolved technical problems appearing in the booklet, which was first issued in April, 1952, and revised in April, 1953, and January, 1954.

The booklet – copies of which may be obtained without charge from the Society, at 1916 Race-street, Philadelphia 3, Pennsylvania, U.S.A. – has been compiled by the organisation's Administrative Committee on Research.

TECHNICAL SUBJECTS DISCUSSED

The problems included in the booklet cover the following technical fields, not all of which are dealt with in this article :—lime, concrete and mortars; road and roof materials; refractories; paper and wood; petroleum products and lubricants; electrical insulation; corrosion, electrical deposits and metal coatings; copper and its alloys; and the fatigue of metals, wood and other materials.

All the problems considered in the booklet are presented in the same manner, under a title and the name of the A.S.T.M. research committee responsible for covering the field in which the problem occurs. The problem is then outlined and the present state of knowledge on the subject summarised; a number of questions are submitted, and, finally, references are listed to works which might serve to introduce the subject, and to sources of further information. A selection of these problems is similarly treated in this article but with the omission of references and the names of the committees concerned.

Mechanism of Stress Corrosion Cracking

Problem.—Many metals or alloys when exposed to mildly corrosive environments in a stressed condition develop cracks. Disastrous failures of structural members can result from such stress corrosion cracking. It is particularly unfortunate that frequently the conditions that cause the most rapid stress corrosion cracking failures are those which give only mild or negligible general corrosion. Thus, a stressed part that appears uncorroded to the eye may suddenly fail by stress corrosion cracking. For certain specific metals or alloys in specific environments, the mechanism of stress corrosion cracking appears to be well established. For many other metals or alloys in numerous environments no reasonable mechanism has yet been proposed. Several different mechanisms may be active under different conditions. Sustained research is necessary to provide a better understanding of the causes of this disastrous form of corrosion.

Present State of Knowledge.—The " season cracking " of brass and the " caustic embrittlement " of steel boilers have been known for years. Both of these phenomena appear to be examples of stress corrosion cracking. Much has been written about these types of failure but the mechanism is still obscure. The mechanism of the intergranular stress corrosion cracking of the duralumin type alloys appears to be fairly well established, but the mechanism of transgranular stress corrosion cracking of magnesium-base alloys and of austenitic stainless steels is not understood. A summary of current knowledge of stress corrosion cracking is available in the book entitled *Symposium on Stress Corrosion Cracking of Metals*, that was published jointly by the A.S.T.M. and the A.I.M.E. in 1944.

Questions that Need to be Answered:

1. What is the effect of stress in promoting stress corrosion cracking?
2. Why is the path of stress corrosion cracks transgranular in some cases and intergranular in others?
3. Is the mechanism of all stress corrosion failures electrochemical in nature?
4. If large numbers of stressed specimens of a specific metal or alloy are exposed simultaneously, why do some specimens fail by stress corrosion cracking while similar specimens do not?
5. How can stress corrosion cracking be prevented?

Durability of Concrete

Problem.—Portland cement concrete is the most commonly used structural material where known strength and adequate resistance to the disintegrating forces of natural exposure are important factors. The present state of knowledge enables the engineer adequately to design for strength. It does not make full provision for designing for adequate durability where severe weathering is encountered.

Present State of Knowledge.—The weathering failure of concrete is generally considered to consist of two major types of deterioration, and a combination of these disintegrating factors:

1. Failure in resistance to freezing and thawing, wetting and drying, and associated temperature changes – conditions ordinarily encountered in temperate climates.
2. Failure due to chemical reaction between the cement and certain aggregates frequently used in concrete construction. This reaction is frequently referred to as alkali aggregate reaction.

The chemical composition of the cement has not been shown to have any significant relationship to the resistance which concrete offers to ordinary weathering action.

The inclusion of 4 to 6 per cent., by volume, of air in concrete has been found to increase substantially the resistance to freezing and thawing.

High alkali cements (0·80 per cent. or more) have been found to be very likely to cause adverse chemical reaction between the cement and certain aggregates, particularly aggregates containing opal, and certain volcanic glasses. There is reason to believe that other characteristics of the cement also effect this reaction or produce similar reactions.

Questions that Need to be Answered:

1. What is the mechanism which causes the failure of Portland cement concrete under normal outdoor exposure to weathering action?
2. What characteristics of the cement and aggregate, physical and chemical, affect resistance to weathering?
3. What are the effects of construction practices, handling, placing, finishing and curing, upon concrete durability?
4. What are the chemical and physical reactions which cause concrete failure with certain cement aggregate combinations?

Present tests for all types of durability are inadequate, and much needed work must be done to develop significant tests to measure these properties.

Dimensional Stabilisation of Wood

Problem.—To find new, more effective, and more easily applied means of stabilising the across-the-grain dimensions of wood as influenced by moisture changes.

Present State of Knowledge.—Three principles have been developed by which the across-the-grain dimensional stabilisation of wood can be accomplished: (1) chemically replacing hydroxyl groups with less polar groups; (2) bulking the fibre; and (3) creating chemical cross-bridges between the structural units. The best methods to date, namely, forming resins within the cell-wall structure and acetylation, fall into the second class. Class 2 methods, however, use more chemical than is desired and resin treatment embrittles the wood. Theoretically, method 3 appears the most promising. This method has thus far been accomplished only by treating the wood with formaldehyde vapour. To take place, however, this reaction requires a pH of about 1. This acidity alone badly embrittles wood.

Questions that Need to be Answered:

Cross-linking agents should be sought that react with hydroxyl groups in a practically neutral medium.

Non-Destructive Tests for Wood

Problem.—To develop rapid practical non-destructive tests for closely evaluating the strength of individual pieces of timber containing knots and other natural characteristics as an effective means of improving the efficiency of structural timber utilisation.

Present State of Knowledge.—Individual pieces of wood of any species exhibit a wide range of strength properties. Present methods of structural grading, based on an evaluation of the physical characteristics through visual inspection, afford safe and effective structural grades. However, any structural grade to which working stresses are assigned must reflect the strength of the minimum quality of material in the grade, and consequently contains substantial quantities of higher strength material that is used inefficiently at a lower stress level than it is capable of carrying. The development of non-destructive tests for more closely evaluating the strength of individual pieces of timber would greatly improve

the efficiency of timber utilisation and permit substantial increases in working stresses.

Many data are available on the effect of various characteristics and defects on the strength of timber, and basic principles for structural grades based on the evaluation of physical characteristics by visual inspection have been developed, as presented in A.S.T.M. Method D 245-49 T, *Tentative Methods for Establishing Structural Grades of Lumber*. Study has been made of the relation of density to strength. It has also been shown that a relation exists betwen the slope of fibril and strength and between the slope of fibril and longitudinal shrinkage. Methods have been developed for evaluating strength by sampling and testing. Also, some progress has been made in the development of hardness test methods for use in estimating quality. Further studies have shown the possibility of evaluating modulus of elasticity by non-destructive sonic methods, and indicate that the compressive strength may be related to the logarithmic decrement of the vibrations.

Questions that Need to be Answered:

The basic need is for a non-destructive test method that can quickly be applied to individual pieces of timber, as they flow from the production line, and that will permit an accurate estimate of the strength of individual pieces, thereby permitting classification with respect to appropriate working stress.

Character and Statistical Nature of Fatigue Damage

Problem.—There is need for information about the nature and extent of the damaging readjustments which occur prior to the formation of a fatigue crack in a member subjected to repeated stress. Since metals are polycrystalline, the random variations in strength of individual crystals throughout the structure result in a heterogeneous reaction of the material to the imposed stresses; this leads to statistical variations in results of tests of like specimens under similar conditions. The factors which control the statistical average fatigue strength properties of polycrystalline metals must be known before the designer of machines can predict the most probable fatigue strength of full-sized members subjected to typical service conditions.

Present State of Knowledge.—It is well known that materials subjected to repeated stressing behave in an inelastic manner on a microscopic scale. There is visible evidence of slip within crystals at stress levels below the nominal "elastic strength" of the metal. Some investigators have also reported that initial stresses existing in a member at the start of a test may be vastly altered by the repeated stresses imposed during service. Thus the chance microscopic and submicroscopic readjustments which take place within the metal during repeated stressing lead to marked changed in strength characteristics of the metal. These are of prime importance in controlling the statistical dispersion of life of a particular member under repeated stressing, or in determining the fatigue strength of the member. Since the metal does not behave in accordance with the assumptions of homogeneity and isotropy employed in the theory of elasticity, new concepts of the mechanism leading to the formation of a crack must be developed and correlated on a statistical basis before rational design procedures can be evolved.

Questions that need to be Answered:

1. What is the sequence of mechanical readjustments and strength changes that occur within the crystalline structure during repeated stressing?
2. Upon what factors does the statistical variation in fatigue life of a member depend?
3. Are the structural readjustments that take place within the polycrystalline material the same for ferrous metals as for non-ferrous metals?
4. How can the fatigue life of a member subjected to repeated stressing be predicted from a knowledge of the structure and the average mechanical strength characteristics of the polycrystalline material?

Effect of Local Plastic Flow on the Notch Sensitivity of Metals in Fatigue

Problem.—It has generally been assumed that local plastic flow at the bottom of a notch reduces the stress concentration at this point and so makes the element less liable to fatigue failure. However, there is not sufficient information available to make a quantitative evaluation of this effect, which might be of considerable practical value. Also, some recent work has shown that, while there is a large concentration of strain at points of stress concentration when the local stress exceeds the yield strength of the material, this affects only the mean stress and not the stress range at these points. This indicates that the effect of such local deformation would have only a minor effect on the fatigue strength of a part.

Present State of Knowledge.—Very little exact information exists on this problem. Some studies have been made using X-ray technique to measure the residual stresses near a notch and correlate them with the fatigue behaviour. These have shown that in some cases there is a beneficial effect of local plastic deformation due to the residual compressive stress set up a short distance below the bottom of the notch. This decreases the rate of propagation of the fatigue crack through the region, although no change had been found in the number of cycles required to initiate the crack. Undoubtedly more information can be obtained by a critical study of the extensive data concerning the effect of notches on fatigue properties, but most of these data are of little value because the condition of the surface of the metal in the notched specimens has not been the same as that in the smooth specimens.

Questions that Need to be Answered:

1. How does the occurrence of plastic deformation near the bottom of a notch affect the relation between the range of applied load and the range of stress at the point of stress concentration?
2. Does this range of stress remain constant after many repetitions of stress?
3. Is the fatigue behaviour of the metal at the bottom of a notch, for a given stress range, the same as the behaviour of a smooth specimen, for the same stress range ?
4. What is the effect of the residual stress due to plastic deformation on the propagation of fatigue cracks?
5. If there is an increase in fatigue strength due to plastic deformation at the bottom of a notch, can this effect be applied to increase the fatigue strength of actual structural elements subjected to fluctuating loads?

Effect of Shape of Notch

Problem.—Machine parts commonly fail at regions of geometrical discontinuity, such as grooves, fillets, oil holes, keyways, and other necessary notches. Laboratory investigations have covered, to some degree, the effect of a particular notch upon different materials, and, also to a certain extent, the effects of notches of different severity upon a material. However, for adequate design of parts and structures, information is needed concerning the extent to which shape as well as severity of notch may influence fatigue strength.

Present State of Knowledge.—Experience has shown that sharp notches may be very detrimental to parts that undergo repeated stressing. On the other hand experience also teaches that sometimes small scratches on large parts do not develop so drastic a reduction in fatigue strength as might be feared.

Laboratory investigations have shown that the theoretical stress concentration factor is not a sufficient index of the influence of a notch upon fatigue strength. There is considerable evidence that the radius of the root of a notch in addition to the theoretical stress concentration factor may be important in determining the fatigue strength caused by the notch.

Questions that Need to be Answered:

1. What is the influence of root radius upon the fatigue strength reduction caused by a particular type of notch (such as a circumferential groove) of fixed severity, in various materials?
2. Does this influence vary with notch severity?
3. Is it independent of notch shape, or must this be further investigated for different types of notches (for example, grooves, fillets, transverse holes)?
4. Is the influence of notch shape different for different types of loading (tension, torsion, bending)?
5. Is the influence of notch shape (particularly root radius) related to the grain size of the material?

Effect of Size and Shape of Member Upon Fatigue Behaviour

Problem.—Difference in specimen size and shape result in data of uncertain compatibility (both from laboratory to laboratory and from one type of test to another). Information is needed to distinguish between the effect on fatigue strength and on scatter in fatigue test results of (1) the volume of highly stressed materials, (2) the surface finish, and (3) the stress gradient.

Present State of Knowledge.—Size and shape of the test specimen appear to affect fatigue test results, particularly in repeated bending tests. In tests reported to date, different fabrication techniques probably introduce variability in surface effects when specimens of different shapes are made. Differences in specimen size usually involve both a difference in the volume of highly stressed material and in the stress gradients involved; investigations designed to separate these effects have not been generally reported.

Questions that Need to be Answered:

1. What is the effect of the volume of highly stressed material on fatigue results (under conditions of constant surface finish and stress gradient)?
2. What is the effect of surface finish (including not only "smoothness" but basic preparatory techniques) on fatigue results (under conditions of constant volume of highly stressed material and constant stress gradient)?
3. What is the effect of the stress gradient on fatigue results (under conditions of constant volume of highly stressed material and constant surface finish)?

Effect of Various Factors on the Fatigue Life of Materials

Problem.—Because of the present great interest in fatigue life and in the fatigue limit, it would be desirable to make a systematic study of the various factors that may affect fatigue life. These would include surface finish, surface treatment, frequency of repetition, overstressing, understressing, coaxing, etc.

Since scatter of results is always present in fatigue life tests, it would be especially desirable to determine whether certain factors induce less scatter than others.

Present State of Knowledge.—Some of the factors mentioned above have been encountered in studying the relation between stress history and fatigue damage. In the past, various factors that influence fatigue limit have been studied, and it now seems desirable to know also what their effect is on fatigue life.

Questions that Need to be Answered:

1. When fatigue life tests are made on several different machines of the same type, are the results directly comparable or must one suspect a machine factor?
2. When fatigue life tests are made on machines of different types, are the results comparable?
3. What are the causes of scatter in fatigue life tests?
4. Is it possible to use a surface finish which will hold scatter to a minimum?
5. Is scatter of results partly due to the fact that we have no precise criterion of what constitutes fatigue failure?

Evaluation of Fatigue-Notch Sensitivity Index

Evaluations of fatigue-notch sensitivity, according to existing definitions, do not afford a value for this property constant for a specified material. It would be desirable for designers to determine an index of fatigue-notch sensitivity that would be an unambiguous characteristic of a metal – at least, within the elastic range.

Present State of Knowledge.—To date, fatigue-notch sensitivity has been designated in terms of (1) a measured fatigue strength reduction factor, K_f and (2) a theoretical stress concentration factor, K_t. It appears that K_f varies, not only with K_t and with material, but with other conditions, such as: shape and size (particularly, root radius) of notch; residual stress induced in preparation of the notch; stress levels and other loading conditions; and material grain size and structure. A number of suggestions as to the most important of these conditions have been offered: local non-homogeneity and anisotropy of material, volume of material at peak stress, stress gradient, etc. Insufficient information is available to separate the possible influences of such factors.

Questions that Need to be Answered:

1. What is the effect of notch radius of K_f?
2. Is this effect in accordance with the theory advanced by H. Neuber in *Theory of Notch Stresses* (J. W. Edwards Press, Ann Arbor, Michigan, U.S.A.)?
3. What is the effect of residual stress introduced at the notch root by specimen preparation?
4. How does volume of material at peak stress and stress gradient at notch root affect K_f.
5. What is the effect of grain size and structure of material?
6. Can the effects of these variables on K_f be separately determined?
7. When the effects of the above variables on K_f are more adequately understood, can a more useful index of fatigue-notch sensitivity be proposed?

Fatigue Properties of Fully Hardened Steels

Problem.—Many machine parts such as ball and roller bearings, springs, gears, etc., are subjected to a large number of cycles of stress in normal service and are heat treated to hardnesses exceeding 45 Rockwell C. Only scanty data are available regarding the fatigue strength and notch sensitivity of steels heat treated to high hardness levels. Furthermore, little is known regarding the residual stresses existing in drastically quenched steels and the extent of their influence on the fatigue qualities of the metal.

Present State of Knowledge.—Tests of ball and roller bearing assemblies have indicated that no definite fatigue limit exists, but that fatigue failure will eventually occur (even at relatively low stress levels) if the loading is repeated a sufficient number of cycles. The general impression exists that steels having high hardness are relatively more notch sensitive than those of low hardness, but recent unpublished data seem to indicate that this may not be true. If the heat-treating operations leave the surface material of the finished part with inherent residual compressive stresses, the fatigue strength of the member should be improved, whereas residual tensile stresses in the surface layers may markedly reduce the fatigue strength. Variations in the processing (including quenching, tempering, machining, grinding, etc.) may therefore produce wide differences in fatigue resistance of the member. Methods of manipulating the heat treatment such as delayed quenching, iso-thermal quenching, as well as the types and severity of final grinding operations may be of prime importance.

Questions that Need to be Answered:

1. Do steels that have a hardness higher than 45 Rockwell C exhibit a definite horizontal asymptote in the *S-N* diagram?
2. What relation exists between the hardness of the steel, the surface residual stresses, and the final fatigue strength?
3. Are the initial residual stresses stable, or does the repeated stressing alter the residual stress pattern?
4. Are steels heat treated to a high hardness highly notch sensitive?

Fatigue Properties of Timber Fasteners under Repeated Loads

Problem.—The design of the connections in any structure or article made of wood is most critical. Nails, bolts, screws, and connectors are among the mechanical fastenings most commonly used for joints in wood. No concrete data are available on how joints using these types of fastenings withstand repeated loading. Because in many designs the joint in any member is the limiting factor in the design, basic information on the resistance of typical joints to fatigue loading is needed.

Present State of Knowledge.—In wood the appearance of a fatigue failure is not greatly different from that due to a static loading. Thus, in service it is difficult to determine whether the cause of failure can be definitely attributed to fatigue rather than structural damage due to a single loading. There has been little or no test work on the fatigue resistance of mechanically fastened joints; any work started should be directed toward obtaining fundamental information.

Tests of this type should simulate typical joints as actually used, to obtain data on how some of the simpler joints react when subjected to repeated loading. For example, in the sway bracing on a timber trestle, a 4-in. by 8-in. diagonal member is bolted to a pile or 12-in. by 12-in. post using a ¾-in. diameter bolt and a grid plate. The loading on this joint could be simulated in test and *S-N* curves be determined for repeated loadings.

Questions that Need to be Answered:

Information on the behaviour of mechanically fastened joints will assist the designer in making a rational analysis of structures that are subjected to repetitive loading.

Fatigue Strengths of Metals Subjected to Combined Stresses

Problem.—Many machine and structural parts are subjected to combined stresses rather than simple stresses acting in one direction. Although some test results are available that give the influence of some biaxial stress conditions on the fatigue strength, there is need for further study of this problem.

Present State of Knowledge.—There is some information on fatigue strengths of metals subjected to biaxial tension-tension and biaxial tension-compression stresses. These data are for either completely reversed stresses or for fluctuating stresses with a minimum value of zero. Furthermore, relatively few materials have been studied and few tests made for those stress combinations that have been studied.

Questions that Need to be Answered:

(1) What theory best agrees with the test results for biaxial tension-tension and biaxial tension-compression stresses?

(2) What is the influence of the range of stress on the combined fatigue strengths in question (1)?

(3) What is the behaviour of the material under fatigue biaxial compressive stresses?

(4) What fatigue strengths can be expected under various types of triaxial stresses?

Relation between Stress History and Fatigue Damage

Problem.—The data contained in the conventional *S-N* diagram obtained from fatigue tests under constant stress amplitude do not express the changing characteristics of the metal induced by overstressing, understressing, or rest periods that are inherent in the normal stress history of a machine part. Information is needed to determine the effect of fluctuations in stress amplitude on the fatigue life of a member. This problem is closely associated with the need for basic information leading to a knowledge of what constitutes fatigue damage in members subjected to a variable stress history.

Present State of Knowledge.—Present design practices assume that repetitions of a stress below the fatigue limit of the material develop no damage, whereas repetitions of a stress above the endurance limit develop damage in proportion to the number of cycles of the overstress (that is, the damage is assumed to be equal to n/N, where n is the number of cycles of stress imposed, and N is the number of repetitions of stress to the normal *S-N* diagram at that stress level). However, the available data indicate that: (1) the fatigue limit may be markedly altered by a previous stress history; (2) the proportionate damage is not a simple linear function of the cycle ratio; (3) repetitions of stress below the original endurance limit may cause damage if the previous stress history includes repeated overstressing; and (4) by repeatedly stressing just below the fatigue limit and periodically increasing the load by a small increment after a large number of stress cycles at each increment (called "coaxing"), the life at the higher stress levels may be prolonged far beyond that predicted by the ordinary *S-N* curve.

Questions that Need to be Answered:

1. What is the mechanism that constitutes fatigue damage?
2. Why is it that fatigue damage in steel does not accumulate as rapidly at a given level of stress if the member is subjected to "coaxing" (with relatively small stress increments and a large number of cycles at each of the successively increasing stresses)?
3. How can the fatigue life of a member subjected to a variable stress history be predicted from the data obtained in conventional laboratory tests?

Study of Crack Genesis and Growth in Steel

Problem.—There is experimental evidence that test bars having extremely high stress concentration may show cracks at stress levels well below the endurance limit for such test bars. More information is required on this aspect of the fatigue problem.

Present State of Knowledge.—Tests in rotary bending show that for the case of a sharp notch in low-carbon steel with an endurance limit of ± 26,000 lb. per sq. in., cracks may develope at stresses of only 10,000 lb. per sq. in. Whether such cracks spread has not been clearly established due to the difficulty of determining the presence of cracks of a depth of 0·001 in. or less. Similar results have been obtained for much larger specimens under cyclic direct stress. A great deal of data is also available on the growth of cracks at press fit assemblies.

Questions that Need to be Answered:

1. Under what conditions will cracks develop and will these be the same for carbon and alloy steels?
2. Under a constant range of stress these cracks may not spread but under a condition of high peak stresses is this still true?

Paper and Paper Products

A number of problems concerned with the technology of paper are also presented in the booklet. They deal with such subjects as the appearance, erasability and formation of paper, the siliceous grit of paper and the tension testing of paper.

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INSTRUMENT FACTORY ENLARGED

Production Lines Improved

The Longacres works at St. Albans of Marconi Instruments, Limited, has been enlarged by the opening of a new wing. There has also been some reorganisation to improve the flow along the production lines, and a design centre has been added. During the seven years that the works have been at Longacres, they have been more than trebled in size to meet the increased demands for the testing instruments and electro-medical equipment made there.

CONTINUOUS SIEVING

PLANT FOR HANDLING LIQUIDS OR POWDERS AT HIGH OUTPUTS

There can be very few processes in the chemical industry which do not involve at some stage the sieving or straining of the material. In many it is all-important as the texture of the final product depends upon its components. Reciprocating shakers have the disadvantage that the mesh tends to become clogged by oversize particles which wedge in the interstices and are hammered in by the action of other particles. Therefore, at the beginning of the last war, Russell Constructions, Limited, 8 Adam-street, Strand, London, W.C.2, started to develop an alternative sieving action, particularly for highly sensitive explosive powders. This article is based on information kindly supplied by them.

ROLLING MOTION

It was found that by imparting a gyratory motion to the screen, the dangerous violent reversals were avoided and the particles rolled over the meshes. As a result of the rolling, the particles did not become wedged in the screen but they remained closely in contact with it at all times. Another discovery was that, if the depth of material was not great, the particles tended to take a spiral path outwards from the centre and the oversize ones eventually collected around the rim. A circular screen was found to be better than a rectangular one for dry powders, as the motion is uniform over the whole surface.

In these machines, the gyratory motion is imparted to the screen by an out-of-balance flywheel. It should be explained that the screen itself does not revolve, the motion being equivalent to that which would be caused by a very small crank operating at the centre, or as if the screen formed the strap of an eccentric. In the early models, shown in Fig. 1, the electric motor drove the flywheel directly, and the whole machine was suspended from the ceiling. This gave very good results, and could even be used for tracer-bullet powder, which is one of the more sensitive of the explosives. However, they had the limitation that they could only be used where there were facilities for suspension, and consequently attention was directed to producing a stand model.

PORTABLE MODELS

The first stand model produced is shown in Fig. 2. As can be seen, it is mounted on three wheels and so can be moved as desired. It differs from the suspension model in that the motor is rigidly fixed to the static frame and drives the flywheel through a special flexible coupling. The sieve and flywheel mountings are suspended from the upper ring of the static frame by three steel rods mounted in rubber bushes. One of these rods, the flywheel and the flexible drive coupling are shown in Fig. 4. These machines gave excellent results using screens as fine as 300 mesh.

Practical experience showed that there was an optimum working speed for each powder, and therefore a variable-speed machine was produced incorporating a torque-converter and capable of operating between 1,000 and 3,500 cycles per minute. Fig. 3 is an illustration of this model. By finding and running at the optimum speed, very large outputs were obtained—for example, cornflour could be sieved through a 100-mesh screen of less than 2½ sq. ft. area at the rate of 6 tons per hour when the machine was operating at the higher frequency. Varying the speed from the optimum by 10 per cent. caused a 25 per cent. fall in the rate of sieving. The driving motor in these machines is only ¾ h.p. and they are designed for easy maintenance. The clips which hold the sieve can be seen in the illustrations.

CONTINUOUS FLOW

One disadvantage shared by these stand machines is that they are only suitable for batch sieving; that is, after a time the sieve must be removed and the oversize material tipped out by hand. Obviously this is not a feature which allows them to be used in fully continuous processes, so the next stage in development was a machine which would continuously reject the particles that failed to pass through its screen. This is done in the "Cascade" machine illustrated by Fig. 5 and by the sectioned view of Fig. 6.

In this model, the spiral path of the particles is utilised, the material being fed into the centre opening. The particles move across the horizontal screen, the fines passing through, until they reach the outer rim where they fall on to the guide tray and are returned to the centre of the next screen. Eventually, the oversize particles are rejected from the last rim and pass out of the chute on the right (Fig. 5), and the sieved material is delivered from the pipe on the left. The machine stands 3 ft. 6 in. high, is 2 ft. in diameter and weighs 4¼ cwt. The total mesh area of the three stages is 6½ sq. ft., the height and diameter of the housing being 15 in. and 22 in., respectively. It is completely dust-proof. As the maximum unsupported length of screen is 8 in., it is quite practicable to use nylon or other fabrics. Indeed, using a 40-mesh nylon screen, the output of cornflour was in excess of six tons per hour, without any suggestion of damage to the screen; the operating frequency being 1,475 cycles per minute and the driving motor ¾ h.p.

For buildings where the material is stored on upper floors, a special model of the Cascade machine has been developed to fit in the floor of the store-room and deliver the sieved product in the room below. This has particularly been used in bakeries, and will pass six tons of flour per hour through a 30-mesh screen. It is a very simple matter to fit new screens, or they can be arranged to be interchangeable.

One of the great advantages of the gyratory motion is that the particles do not jump clear of the screen and therefore do not get the hammering encountered with reciprocating sieves. This point has already been mentioned in connection with explosives, but it also applies to materials with a high fat content, such as cocoa powder. This particular substance can give great trouble in sieving, as rough treatment turns the powder to a paste and completely blocks the

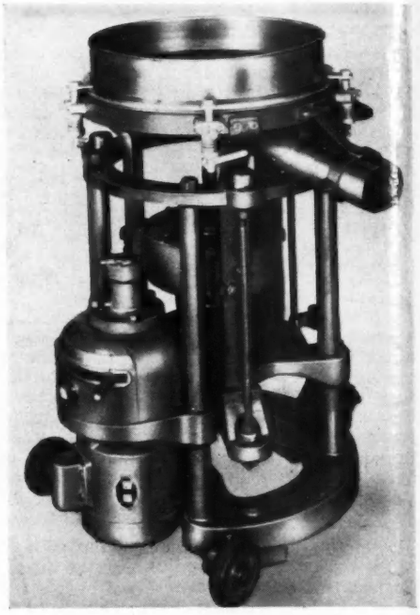


Fig. 3 The introduction of a torque-converter enabled the machine to be run at the optimum speed for each powder or liquid.

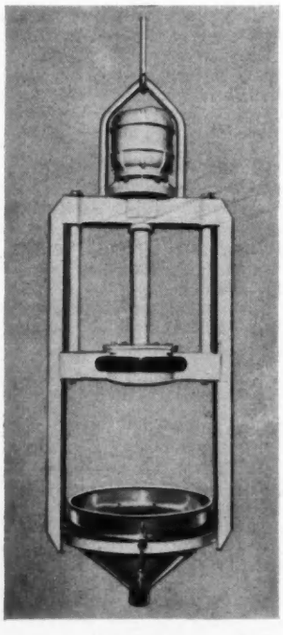


Fig. 1 An early model, suspended from the ceiling

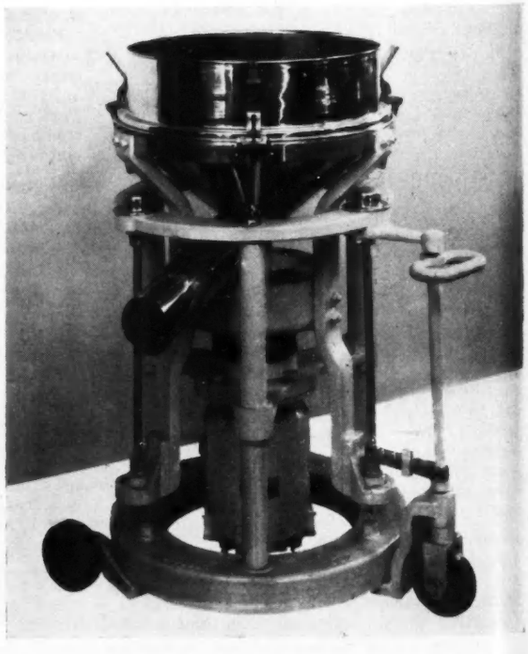


Fig. 2 The stand models could be moved where required, and were made for larger capacities.

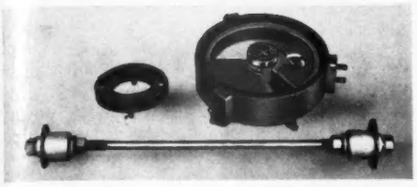


Fig. 4 The flexible drive coupling, the flywheel and a suspension rod used on the stand models.

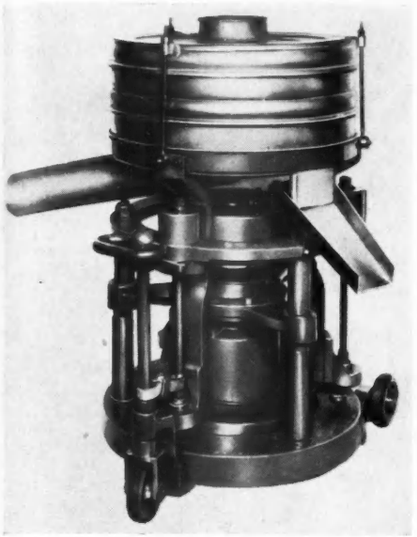


Fig. 5 The Cascade machine gives continuous rejection of oversize material and therefore permits continuous sieving.

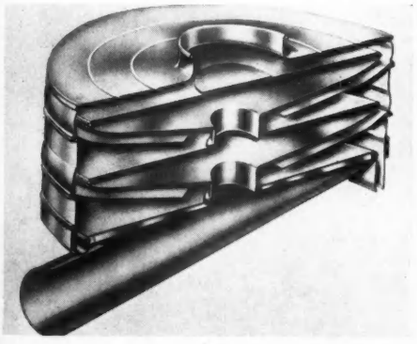


Fig. 6 In the Cascade machine, particles pass over each screen in turn; the filtered product is discharged from the centre and oversize matter from the edge. The process is continuous.

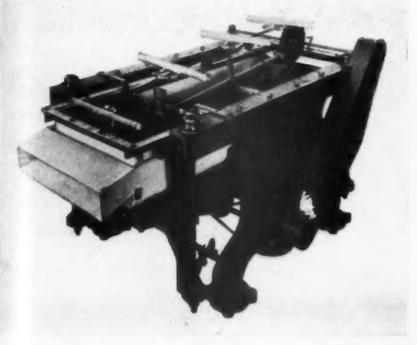


Fig. 7 For continuous straining of liquids, the Separator machine is used. It can filter 18,000 gallons per hour.

screens; the Cascade machine will sift it at 900 lb. per hour through a 100-mesh screen. Similarly, materials which have wedge-shaped particles, such as some plastics and metal ores, benefit by the rolling motion and do not clog the screen.

CHOCOLATE OR TAR

All these machines are equally as useful for straining liquids or semi-liquids as they are for sieving dry powders; whale-oil, molten chocolate or thixotropic paints can all be dealt with. A careful study of the motion, using high-speed cinematography, shows that minute vortices are set up at each hole in the screen, and the liquids " screw " themselves through. Using a mixture of sand and water, it could be seen that the sand particles were repelled and appeared to float on the surface of the water. A separator machine for continuous straining of liquids and semi-liquids is shown in Fig. 7. This machine can pass up to 18,000 gallons per hour through a 100-mesh screen. It has been used for whale-oil, in paper manufacture and in sugar refineries. A more recent application has been to the de-watering of tar, which has always been a problem. The straining of the tar through the separator to remove the solid matter partially breaks down the emulsion and enables the water to be removed by simple centrifuging. Work is now proceeding on the application of the Cascade machine to straining and filtering processes.

LAUNCHES AND TRIAL TRIPS

M.S. " PAN GOTHIA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the Rederi AB Kungsoil, Kungsbacka, Sweden. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in.; deadweight capacity, about 17,600 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder two-stroke single-acting Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Service speed, 15 knots. Launch, February 9.

M.S. " TEMPLE HALL."—Single-screw cargo vessel, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for the Temple Steamship Co., Ltd. (Managers: Lambert Brothers, Ltd.), London, E.C.3. Main dimensions: 425 ft. between perpendiculars by 58 ft. 6 in. by 37 ft. 9 in. to shelter deck; deadweight capacity, 10,400 tons on a draught of 26 ft. 11¼ in.; gross tonnage, 8,003. Vickers-Doxford four-cylinder opposed-piston reversible oil engine, developing 3,300 b.h.p. at 108 r.p.m., constructed by Vickers-Armstrongs Ltd. Service speed, 12 knots. Trial trip, February 10.

S.S. " FREDERICK JOHN EVANS."—Single-screw collier, built by S. P. Austin and Son, Ltd., Sunderland, for the North Thames Gas Board, London, W.8. (Managers: Stephenson Clarke, Ltd., London, E.C.3). Main dimensions: 344 ft. overall by 46 ft. by 22 ft. 4 in. to upper deck; deadweight capacity, about 4,600 tons on a mean summer draught of 20 ft. Direct-acting triple-expansion steam engine of reheat design, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Speed on trial, 11¼ knots. Trial trip, February 18.

M.S. " CHLOE."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for the Maya Compania Armadora S.A., City of Panama. Main dimensions: 560 ft. between perpendiculars by 80 ft. by 42 ft. 3 in.; deadweight capacity, about 24,575 tons on a draught of 32 ft. 3¼ in. N.E.M.-Doxford six-cylinder two-stroke single-acting opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m., constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Speed, about 14 knots. Trial trip, February 18.

S.S. " HAUSTRUM."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for the Shell Bermuda (Overseas), Ltd., London, E.C.3. Main dimensions: 557 ft. overall by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, about 18,000 tons. Double-reduction geared steam turbines, developing a maximum of 8,250 s.h.p., and two Foster Wheeler water-tube boilers. Speed, about 15 knots. Trial trip, February 18 and 19.

M.S. " ANITA."—Single-screw oil tanker, built by the Furness Shipbuilding Co., Ltd., Haverton Hill, County Durham, for Erling H. Samuelsens Rederi A/S., Koppang, Norway. Main dimensions: 525 ft. between perpendiculars by 71 ft. by 39 ft. 3 in.; deadweight capacity, 18,100 tons on a summer draught of 30 ft. 6 in. Hawthorn-Doxford six-cylinder single-acting two-stroke oil engine, developing 6,600 b.h.p. at 115 r.p.m., constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Speed, 15 knots. Trial trip, February 22.

M.S. " MIMOSA."—Single-screw oil tanker, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for the Tankers Shipping and Trading Corporation, Panama. Main dimensions: 550 ft. overall by 66 ft. by 39 ft. 3 in; deadweight capacity, 17,620 tons on a draught of 30 ft. 2 in. Götaverken nine-cylinder two-stroke single-acting Diesel engine, developing 6,750 b.h.p. at 112 r.p.m. Speed, fully loaded, 15 knots. Delivered, February 23.

CARGO VESSEL CONVERTED FOR CABLE LAYING

In order to resume the cable-laying side of their business at an early date, Submarine Cables Limited, Telcon Works, Greenwich, London, S.E.10, a joint subsidiary of Siemens Brothers and Company, Limited, and the Telegraph Construction and Maintenance Company Limited, have purchased the s.s. Empire Frome, a cargo vessel of 5,360 tons deadweight, for conversion into a cable ship. The vessel is considered to be basically suitable for cable laying and, as her conversion to this work is expected to take no more than twelve months to complete, the firm will be able, in this way, to put a cable ship into service much more quickly than if a vessel were to be built specially for the work.

After conversion, the Empire Frome, which has a length of 360 ft. and a beam of 51 ft., will possess four cable tanks, with a total carrying capacity of 3,750 tons, equivalent to some 1,200 nautical miles of the lighter types of deep-sea cable. The full complement will be about 90 officers and men.

The vessel will be supplied with machinery to enable her to lay cables varying from normal weights up to the heaviest power types, and also to place in position the rigid and flexible submersible repeaters which are inserted at intervals along submarine telephone-cable lines. During conversion, the ship will be fitted with a Pleuger activated rudder and will be the first British vessel to be so equipped. She will be moored at Greenwich and will be available for chartering by the various cable-operating companies. Before taking over her new duties, she will be renamed the s.s. Ocean Layer.

On their formation in 1935, Submarine Cables acquired two cable ships from the parent organisations: the Dominia and the Faraday. The former was sold in 1937 and the latter was destroyed by enemy action near Milford Haven in 1941.

* * *

FILM ON PRODUCTION AIDS

A 50-minute film made by Philips Electrical, Limited, 122 Brixton-hill, London, S.W., illustrates how their products may be used in production. The title of the film is " A New Approach to Production Improvement," and it may be borrowed, free of charge, from the company. All forms of electric welding are shown, including multi-point automatic machines and portable resistance welders. One machine makes long welds by using a series of electrodes so placed that as one is used up the next comes into action. Magnetic filters are also shown in many applications. Various examples of induction and dielectric heating are given and the film includes pictures of the wide range of electronic instruments made by the company.

THE WORK OF THE ROYAL AIRCRAFT ESTABLISHMENT

A sketch of some of the activities and inventions of the Royal Aircraft Establishment was given in London on March 4 by the Director, Professor A. A. Hall, F.R.S., in a lecture entitled "The Work of the Royal Aircraft Establishment," before the Royal Society. He explained that the R.A.E. was concerned with scientific research in all aspects of aviation and guided weapons other than turbine engines and radar, which were undertaken at separate establishments. A very large part of the work was carried out in the air, and he paid tribute to the pilots undertaking these often hazardous experiments.

In experimental aerodynamic investigations, the R.A.E. used wind tunnels, piloted aircraft and powered models launched into free flight. It was necessary to reproduce the Reynolds number, Mach number, and turbulence criteria applicable to the flight conditions being investigated or to extrapolate for "scale effect." Generally, it was essential that the correct Mach number should be achieved. It was not, however, practicable, on the score of cost, to provide wind tunnels for the Reynolds numbers at which aircraft operated in flight; but if the range of extrapolation was not too great, wind tunnels could provide a flexible tool. Tunnel turbulence was of smaller scale, but of greater amplitude than that encountered in flight well clear of the ground. Research in wind-tunnel design, in which the Establishment had taken a leading part, had enabled the amplitude to be limited sufficiently for many purposes.

To offset the limitations of wind tunnel work, flight research provided high Reynolds number effects and low turbulence conditions; high Reynolds numbers could also be achieved in small powered model tests, owing to the high density of the air at ground level. The three techniques were complementary.

STRAIN MEASURED ACCURATELY TO 0·0001 PER CENT.

The Royal Aircraft Establishment had become the centre for large wind tunnels provided on a national scale for carrying out aircraft development, in close collaboration with the designing company. Professor Hall showed a slide of a model Comet air-liner under test in such a tunnel. The model was supported on a slim six-component strain-gauge balance, developed at the Establishment to reduce the blockage correction when working at near-sonic speeds. This, he said, was a rather special application of the electrical resistance strain gauge in that an accuracy of 0·0001 per cent. had been achieved.

Professor Hall then discussed some of the problems of longitudinal stability. Realising that serious non-linearities were likely to arise as aircraft speeds approached that of sound, investigations on the stability of specially-prepared Spitfire aircraft dived from high altitude were put in hand in 1942. Later, wind-tunnel and powered model tests were added to the programme. These tests revealed the rapid change in effectiveness of aerodynamic controls and the total collapse of short-period longitudinal damping in the transonic region. In one example shown (which, Professor Hall said, was not typical), a complete reversal of control effectiveness was obtained.

In using powered models for such tests, the control was set at a fixed angle and the resulting rate of roll was observed as the model speed changed, by ground observations (photographic or radar) or by telemetry. Oscillation was obtained by disturbing the flight of the powered model by a control movement or by a small rocket attached to the model. Damping, which could not be satisfactorily determined in the wind tunnel, could also be measured on a piloted flight; great care was essential in such dangerous tests.

3,000-LB. PER SQ. IN. PLASTIC PRESSURE VESSEL

As an instance of the contribution made by the Establishment to the development of aircraft materials, Professor Hall showed some of the work of the Plastics Division – a resin-bonded asbestos plastic wing, a radome in which a light-weight foamed resin filler was sandwiched between resin-bonded glass laminates, and a glass-fibre resin-bonded pressure vessel which had withstood a test pressure of 3,000 lb. per sq. in.

Fatigue was a problem for which no basis of fundamental understanding existed. The R.A.E. Metallurgical Department, in studies of the effects of fatigue stresses on the microstructure of pure aluminium and simple binary alloys, had discovered an interesting phenomenon in a 4-per cent. copper-aluminium alloy, in which thin ribbons of metallic material were exuded from the slip planes under cyclic stressing. This left crevasses in the material. At low temperature, exudation was inhibited, while at high temperatures the thickness of the ribbon increased. No explanation had yet been found.

Meanwhile, means had to be found to protect aircraft from catastrophic fatigue failure. This was tackled in two ways – by a systematic exploration of the gusts encountered on the world's air routes, using specially designed counting accelerometers, and by systematic investigations on the fatigue properties of main wing spar joints and typical complete structures, such as Meteor tail planes. Complete aircraft had also been subjected to alternating load to determine their behaviour. (The Comet air liner, undergoing such tests, had already withstood more than 10,000 flying hours with no sign of any major deterioration.) In this way, it had been possible to state a limit of life for the aircraft under consideration.

In contrast to the fatigue problem, the physics of flutter – a self-excited oscillation arising from the coupling of structural and aerodynamic forces – was well understood; the difficulty lay in solving the complex equations, and in non-linear effects which were difficult to handle analytically. The R.A.E. was concerned with the evolution of design criteria to avoid flutter, and with determining the likely flutter characteristics of complete aircraft. Considerable aid in solving the equations was now available from calculating machinery. In flight tests on flutter, the mode under investigation could be excited by out-of-balance exciters or by using small rockets to provide an impulse. The danger was minimised by approaching the likely flutter speed gradually; the trend of the damping/speed curve towards zero damping would usually reveal the flutter speed. Despite such precautions, flutter was occasionally encountered unexpectedly.

As an example of some of the work on equipment carried out at Farnborough, Professor Hall demonstrated a film showing the pattern of lighting seen by a pilot landing an aircraft at night, or in bad visibility, at most major airports in the world. By introducing the effects of perspective, the "cross-bar" approach lighting, invented by Mr. E. S. Calvert, had overcome the difficulty that a banked aircraft might, to the pilot, appear to be flying along a central line of runway lights when, in fact, it was to one side of them. An analogue computer had been used in developing the system which enabled the landing operation to be simulated under a wide variety of weather conditions and control characteristics.

RADIO TELEPHONY OVER LONG DISTANCES

The lecturer also demonstrated a recording of two radio transmissions from an aircraft flying over Syria, one using normal radio-telephone equipment with double-sideband modulation, and the other using a system developed at the Royal Aircraft Establishment in which the carrier wave was suppressed and all the energy and information concentrated on one sideband. By this means a distinct gain in power could be obtained. Whereas the first transmission was noisy and, to the untrained listener, unintelligible, the single-sideband transmission was clearly heard and understood.

The Chemistry Department had played a large part in research on the starting, spreading and suppression of fires and, in conjunction with the Mechanical Engineering Department, had helped to make fire in the air – once a major hazard – a very rare occurrence.

FLAME RESEARCH

To increase understanding of the new practical problems which were arising with increasing speed and altitude, fundamental studies on the properties of flames were now under way. To overcome the difficulty experienced in spectroscopic work using flames from normal burners, in which it was impossible to decide on the position of the various emitters and in which the spectrum was often masked by the strong continuum of the luminous carbon zone, a special burner had been constructed giving a two-dimensional diffusion flame in which the emitter could be located exactly; absorption spectroscopy could also be used.

In studies of flames of hydrocarbons with nitrogen dioxide as the oxidant – relevant to rocket propulsion – it had been found that combustion occurred in steps and the flame had two reaction zones. By arrangement of the burner size the second zone could be quenched. Analysis of the products of the first zone had shown that the composition of the gases did not correspond to the theoretical equilibrium composition calculated from the temperature; evidently some reactions were taking place over others.

Probably the Royal Aircraft Establishment now had the largest collection of calculating machinery in the United Kingdom, both analogue and digital. Analogues, though usually less accurate, made possible the examination of systems including non-linearities from actual components and human responses. As mentioned earlier, a successful analogue machine had been developed for solving the equations of flutter. Analogue machines were also extensively used for investigating the control problems of guided weapons.

In the digital field, the Establishment were developing machines of the decimal type with facilities for high-speed input on card or type. In wind-tunnel work, raw data could be passed automatically to such machines and processed. A typical machine was the R.A.E. Isograph for solving polynomial equations up to the sixth degree. This machine, although not unique in conception, represented an advance on previous machines in that it required no scaling of the equation, and any coefficient or root could lie between 10^{6} and 10^{-6}. The accuracy was independent of the size of the root.

ENGINEERING APPLICATIONS OF NYLON

HIGH TENSILE STRENGTH

The many uses of "Akulon," a nylon type material, were shown at an exhibition organised by the Hercules Powder Company, Limited, 140 Park-lane, London, W.1, who are the distributors of the material in this country. Akulon is a polyamide plastic manufactured by the Algemene Kunstzijde Unie N.V., Arnhem, Holland, and sold by them as raw material. Many of the manufactured articles shown were the products of British firms. Items can be extruded, injection moulded, centrifugally cast or machined from rod or sheet; a wide range of colours can be obtained.

Akulon has been developed as a special grade of nylon for technical and industrial applications. It has a wide range of uses in the fields of engineering, and also for many other industrial purposes. It has all the family advantages of the polyamides, low specific weight, high corrosion resistance, low coefficient of friction, high wear resistance, high shock absorbency and is unaffected by low temperatures. Its particular properties are: a high tensile strength, with the limit of elasticity at 9,250 lb. per square inch and an ultimate of 37,000 lb. per square inch; the good elongation of 400 per cent.; the high melting point of 220 deg. C.; and the high impact strength of 2·3 ft. lb. per square inch Izod. The specific gravity is 1·13. Akulon can be used up to 120 deg. C. in air, or up to 180 deg. C. in atmospheres from which oxygen has been excluded; there is no deterioration in properties until well below — 40 deg. C.

TEXTILES AND CLOCKS

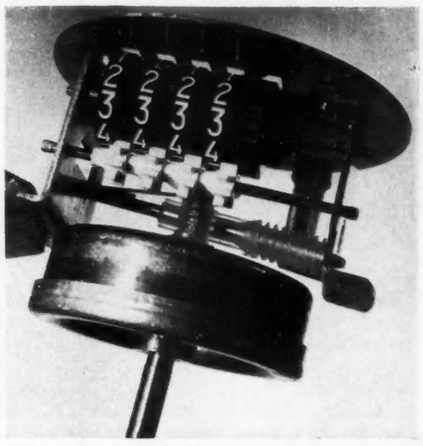
In the field of mechanical engineering, the characteristics that have the greatest appeal are probably its resiliency, high corrosion resistance and small need for lubrication. The last is a great advantage in the textile industries, where fabrics can be badly damaged by chance contact with oily parts and also because there is little tendency for fluff to collect on bearings and gears. The great ease with which intricate parts can be produced by injection moulding is an economic factor of great importance when a single machine requires large numbers of these parts. Also Akulon parts are almost silent in operation and have a life three times longer than steel. For general purposes, Akulon gears can be either moulded or cut and will either mesh together or with metal gears. Lubrication of gears is generally unnecessary, and water is a good lubricant in addition to being a coolant. Very small gears are shown in the illustration of a speedometer, in which several other Akulon parts are also incorporated. Gear trains for electric clocks are another application.

LOCOMOTIVES AND LOCK GATES

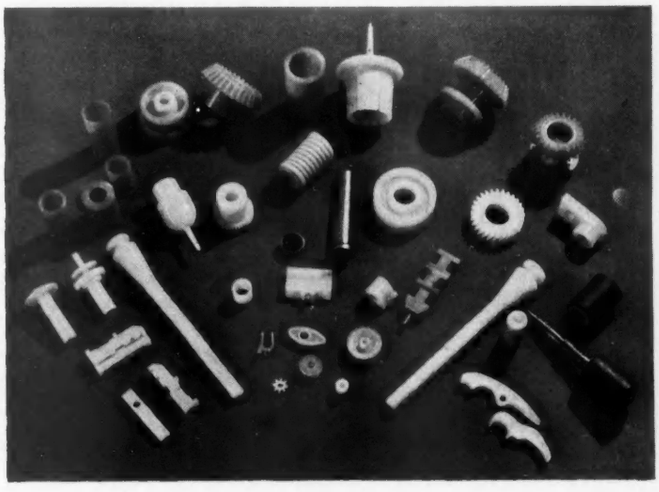
The material can be used in heavy engineering for many purposes; among them may be mentioned guide blocks in the crossheads of steam locomotives and bushes for all types of machines. Indeed, bushes for shackle and king-pins of motor cars can be bought "off the shelf" for standard makes of continental cars. An exact fit with the pin is not needed and standard bushes can be used quite satisfactorily with slightly worn pins. What are, perhaps, the largest bushes made have been used in hanging lock gates; sizes up to three metres diameter having been centrifugally cast for this. Combined sealing glands and tail bearings for launch propeller shafts are also made – the only part not of Akulon being the actual packing. A bush for hanging street signs will last indefinitely and will never squeak.

In electrical fields, applications are at least as varied. Terminal blocks, insulators and moulded cases are in one field, relay switches, interrupter mechanisms and silent gears for cinematographs are another. Akulon can be extruded as a sheath for cables, and for military and aeronautical uses it is extruded over a primary layer of polyvinylchloride, rubber, or polythene. The layer is 0·003 to 0·007 in. thick; such cables conform to official standards for assault-wire. In a similar manner, high-tension overhead cables and wire ropes can be covered with an extruded layer of Akulon which will protect them from corrosion. When joints and splices are made, the coating can be restored by wrapping the joint with film which can be sealed by heat or cement. Complete housings for small motors are made by casting; no machining is needed and the rotor spindle runs directly in the plastic. Fans and nozzles for vacuum cleaners can also be made.

Since Akulon can be sterilised in steam autoclaves or with liquid solutions, it can be used for medical and food equipment. Trays, basins, drinking vessels, blood-transfusion apparatus and needle cases are all in production and, being almost unbreakable, will stand up to the hardest use. Other items now being made are: pressure-type oil cans, with only the nozzle, springs and ball valve of metal; carrying rollers for sliding doors on the Netherlands railways; complete roller bearings, including the rollers; and lock washers which, beside being vibration proof, also make a gas-tight joint. Wrapping films with thicknesses down to 0·03 mm. still have sufficient strength and plasticity to be wrapped tightly around sharp corners without being punctured, affording abrasion and corrosion-proof coverings for parts in transit. A few of the injection mouldings being made are shown in the second illustration.



Speedometer mechanism with Akulon gears and other moving parts. No lubrication is required after assembly and the gears will last longer than steel.



Examples of injection mouldings in Akulon. The mouldings are sufficiently accurate not to need any machining.

* * *

RADIO CONTROL OF MUNICIPAL SERVICES

The City Engineer's Department of Coventry is responsible for 260 miles of street, some 13,000 houses and a large number of public buildings. To facilitate the direction of the necessary repair and maintenance services to the points where they are most required, steps are being taken to link the various vehicles in use by a very high-frequency radio network, which will enable them to be controlled from headquarters.

A tower wagon of the lighting section of the department has been equipped by the General Electric Company, Limited, Kingsway, London, W.C.2, with a combined transmitter and receiver. This will enable the electricians and lighting attendants, who are carrying out repairs to the overhead lanterns, to be directed to places where they are required without first returning to base for instructions. It is hoped to extend the system to the "night scouting" vans which are used to inspect the street lighting and for general patrol duties, as well as to repair vans.

* * *

INSTITUTION OF CHEMICAL ENGINEERS 1954 EXAMINATIONS

The next associate-membership examination of the Institution of Chemical Engineers will be held in London and Manchester on Thursday and Friday, September 9 and 10, 1954. Papers to be worked at home will be issued to candidates on October 1, for return not later than December 15. Application forms, returnable by June 1, and additional particulars may be obtained from the secretary of the Institution, 56 Victoria-street, London, S.W.1.

The whale-catcher "Setter IX," of 3,200 horse-power, is the first British-built ship of its type ; it has a controllable-pitch propeller, electrical-slip engine couplings and a whale-playing winch.

THE WHALE-CATCHER "SETTER IX"

ELECTRICAL-SLIP COUPLINGS AND CONTROLLABLE-PITCH PROPELLER

Whale-catching is a specialised activity requiring, in these days, the use of specially developed vessels which must be capable of sudden bursts of speed, be highly manœuvrable, and also capable of operating away from a base for several weeks at a time and of navigating, not infrequently, through ice-strewn seas. The ideal whale-catcher, therefore, apart from its strictly whale-catching equipment, requires to combine the attributes of a speed-boat with the solidity of an ice-breaker, an ideal not readily attainable but which the Setter IX goes a long way towards realising.

The Setter IX, the first British-built vessel of its type, was built to the order of Hector Whaling, Limited; Walker Crump and Company, Lloyds-avenue, London, E.C.3, acting as consultants. The hull was designed and constructed by A. and J. Inglis, Limited, Glasgow, and has intermediate frames with heavier plating forward to enable the vessel to navigate through floating ice, and in this respect the design meets the requirements of Det Norske Vertias Classification Society.

Reproduced above is a photograph of the completed ship, taken while undergoing gunnery trials, and the situation of the gun platform on the high stem and the provision of an over-bridge connecting it with the wheelhouse deck will be noticed. The vessel is of 707 gross tons, has an overall length of 192 ft., and a length between perpendiculars of 173 ft., a moulded depth of 17 ft. and a designed speed of 14·75 knots when using one of her two main engines; during trials, a speed of 16·75 knots was attained.

ELECTRICAL COUPLING OF THE PROPELLER-SHAFT

The general lay-out of the engine-room is illustrated in the photograph of a model reproduced on this page, and it will be seen that the main propelling and auxiliary machinery is situated in the after half of the ship, so leaving the space forward of the single funnel available for fuel, ballast and fresh-water tanks, the storage of lines, ammunition and other whaling equipment.

The two prime-movers are six-cylinder supercharged, Diesel engines built by the National Gas and Oil Engine Company, Limited, Ashton-under-Lyne, and each engine is continuously rated at 1,360 b.h.p. at 350 r.p.m. with a 12-hour rating of 1,600 b.h.p. at 350 r.p.m. The drive from each engine is taken through electrical-slip couplings to a twin-input gearbox, the single output shaft of which is directly connected to a controllable-pitch fully-reversing propeller.

The electrical-slip couplings, of Asea design, were made in Sweden and supplied by Asea Electric, Limited, Walthamstow. They are of the inner-pole type the outer casings being bolted to the flanges on the output-ends of the engine crankshafts, and the inner rotors being connected to the flanges of the two input-shafts of the gearbox. These couplings are designed for a maximum slip of 1·2 per cent. at full excitation, which demands 14 kW for each coupling.

CONTROLLABLE-PITCH PROPELLER

The main feature of the propulsion system is the provision of a single controllable-pitch fully-reversing propeller in conjunction with a gearbox and two electrical slip couplings; an arrangement which gives the maximum response to demands for power when whale-catching with, at the same time, the maximum economy of fuel.

The propeller fitted is a "Stone-Kamewa" manufactured by J. Stone and Company (Charlton), Limited, 1A, Cockspur-street, London, S.W.1, the sole licensees in Great Britain and, with the exception of Canada, in the Commonwealth, of the Aktiebolaget Karlstads Mekaniska Werkstad, Sweden, the patentees. The design of the Stone-Kamewa propeller, which was fully described in ENGINEERING, vol. 170, page 703 (1950), is based on the Kaplan turbine which employs a propeller-type runner having movable blades controlled in unison with the gate-opening as varying demands for power output are made upon it. The Kamewa propeller has been fitted to ships with up to 7,000 h.p. per propeller-shaft.

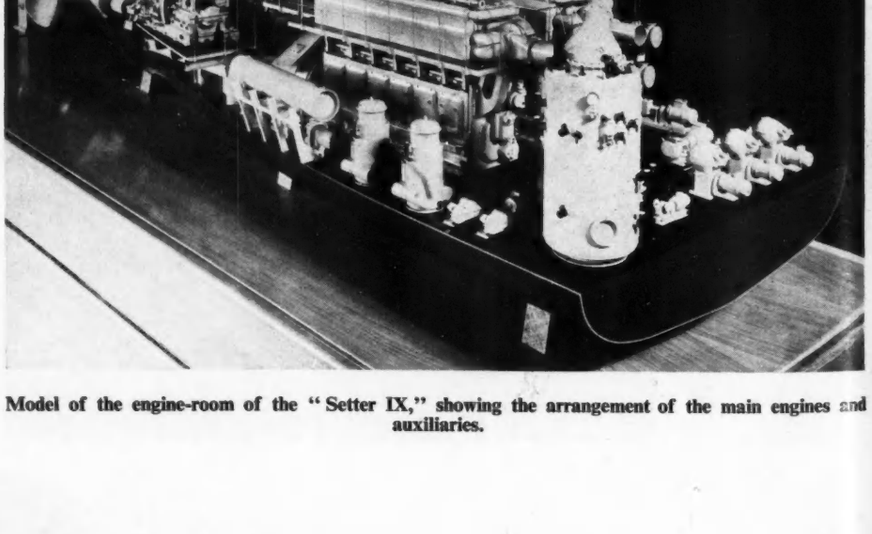
Movement of the blades of the Stone-Kamewa propeller is effected hydraulically by oil pressure, and in the Setter IX, control of the servo-mechanism is arranged to be either in the engine room or, by means of a pneumatic telemotor, from the wheelhouse or from the upper bridge situated on the roof of the wheelhouse.

DUPLICATED MASTER CONTROLLER

A feature of the master controller is the linking of the telemotor operating the propeller-blade servo-mechanism with a second telemotor which controls an oil-operated servo-motor controlling the setting of the two centrifugal engine governors; a second feature is that this master controller may be operated either from within or from the roof of the wheelhouse. As in the case of the servo-mechanism for blade movement, which can be independently controlled from within the engine room, provision is also made for independently controlling the main engines from within the engine-room when required.

The telemotors respectively controlling the propeller-blade servo-mechanism and the servo-mechanism for the setting of the linked engine governors, are mounted in what is termed a "Combinator Column," or master controller, which links the responses of the telemotors to the movement of a single lever. This linking is achieved by two cams mounted on a short shaft which can be moved about its axis by a lever attached to it at one end; this shaft is mechanically linked by bevel gearing to a similar shaft and lever located on the roof of the wheelhouse, or upper bridge. The rotating of the cams by either the lever in the wheelhouse or the lever on the upper bridge controls the valves of the pneumatic telemotors in such a way that, for all positions of the lever from full-speed ahead through neutral to full-speed astern, the pitch of the propeller blades correctly corresponds to the setting of the governors of the main engines.

The speed of the vessel corresponding to any particular position of the master controlling lever is, in consequence, the result of the most efficient propeller pitch and the most suitable engine speed, and, therefore, propeller speed, to suit the speed of the vessel. For convenience, the housing of the master controlling lever is marked with ten positions for ahead running and ten positions for going astern, but there is no notching and there is, therefore, infinite choice between the full-speed ahead and full-speed astern positions of the lever.



Model of the engine-room of the "Setter IX," showing the arrangement of the main engines and auxiliaries.

AUXILIARY MACHINERY

Situated aft of the two main engines are three 100-kW generating sets mounted on a common base-plate placed athwartship above the propeller shaft. The Diesel engines of these sets were made by the National Gas and Oil Engine Company, Limited, and are of a three-cylinder design developing 150 b.h.p. The generators were supplied by Laurence, Scott and Electromotors, Limited, Norwich, and are compound wound for 220 volts. Two of these sets are sufficient to meet the full demand of the ship, the third unit acting as a standy-by.

Other auxiliaries include three electrically-driven de Laval oil-purifiers, Worthington-Simpson fresh and sea-water pumps, together with bilge, ballast, and other special purpose pumps. Two boilers are also provided and the position of one of them, immediately forward of the main engines, is clearly shown in the photograph of the model; this boiler was made by Spanner Boilers, Limited, Streatham, on their "Swirlyflo" principle and can raise 1,100 lb. of steam per hour at 60 lb. per square in. from feed water at 60 deg. F. The second boiler, also of the "Swirlyflo" type, is a waste-heat silencer boiler which is fitted in the uptake from the main engines and is, in fact, the only silencer fitted to them; this waste-heat boiler can supply 2,000 lb. of steam per hour when both engines are running at their continuously-rated full load.

SPECIAL WHALING APPLIANCES

Apart from the forward-mounted gun and numerous navigational aids, including radar, two special pieces of equipment are provided, the first being an echo whalefinder, and the other a whale-playing winch.

The echo whalefinder is fitted in an extension located in the bottom of the ship slightly forward of the foremast; this device, made by Kelvin and Hughes (Marine), Limited, Caxton-street, London, S.W.1, permits of whales being located while under water, and is adapted from the echo-sounder.

The whale-playing winch is placed on the main deck forward immediately aft of the foremast and is the result of collaboration between the Tyne Metal Company, Limited, Hexham, Northumberland, and Laurence, Scott and Electromotors, Limited; it constitutes, we understand, an innovation in whaling technique. The winch is driven by two 60-kW motors and can be controlled manually or left with the controller in, what is termed, the "protected" position, when the winch will automatically play a whale by exerting a continuous and steady pull, paying out line when that pull is overcome by the animal, and taking it in as the pull is relaxed.

Equipment for the electrocution of whales has not been fitted, although provision for its subsequent fitting has been made when certain difficulties have been overcome in the manufacture of a nylon-line which is both light enough and strong enough to carry the conductor enclosed in it.

ADVANTAGES CLAIMED

Several advantages are claimed for the arrangement of the propelling machinery in comparison with that normally installed in a vessel of this size. A considerable saving in space and weight is claimed by using two engines running at 350 r.p.m. rather than one slower-speed unit of equivalent total horse-power directly connected to a single fixed-blade propeller. The provision of two engines driving through electrical-slip couplings, which permit of push-button connection and disconnection from the wheelhouse, gives a high degree of versatility; at the same time, the provision of a controllable-pitch fully-reversing propeller linked with the setting of the engine governors, gives the most efficient propulsive effort to suit various operating conditions of the ship. The master controller gives a high degree of manœuvrability and it is stated that during her trials the vessel was brought from full-speed ahead to a dead-stop in 48 seconds.

OXYGEN FROM LIQUEFACTION AND DISTILLATION OF AIR

FOR DIRECT FLASH SMELTING OF COPPER

In order to have available the very large quantities of oxygen required for the direct flash smelting of copper concentrates at their works at Copper Cliff, Ontario, the International Nickel Company of Canada, Limited, have had installed a "tonnage" oxygen-production plant. Very few data concerning the new oxygen flash smelting process are available for publication, but it is stated that the process eliminates the fuel normally required for smelting and renders economical the present large-scale output of liquid sulphur dioxide from the furnace exhaust gases.

The flash smelting operations at Copper Cliff call for a volume of upwards of 7,500,000 cub. ft. of oxygen every day, requiring the production of 300 tons of 95 per cent. pure oxygen every 24 hours.

The oxygen plant, designed and built by the Canadian Liquid Air Company, Limited, Montreal, and known as an "Oxyton" unit, separates the oxygen from the nitrogen, argon, neon and krypton contained in atmospheric air by a liquefaction and distillation process. Working temperatures within the apparatus range from 80 deg. F. to −280 deg. F., hence special consideration has had to be given to the types of metals and other materials employed in the plant. The regenerator heat exchanger installation consists of two nitrogen regenerators each 8 ft. in diameter and 17 ft. in length, and two oxygen regenerators each 4 ft. in diameter and 14 ft. 9 in. in length. While one pair of regenerators chills the incoming air, the other pair is being chilled by the separator gases. Both regenerators were made from special 8·5 per cent. nickel steel developed by the International Nickel Company for low-temperature applications.

COILED-TUBE HEAT EXCHANGERS

Two wound-coil heat exchangers, constituting part of the plant, are shown in process of fabrication in the illustration below. Each exchanger, which contains 400 copper tubes wound in coil form, is housed inside a steel shell, and gaseous nitrogen at a very low temperature circulates between the inside wall of the shell and the coiled tubes, thus further cooling the liquid air that is passing through the coiled copper tubes. Two other interesting pieces of equipment in the oxygen plant are a very large turbo-compressor required for the initial compression of the incoming air and a specially-built oxygen compressor.

In spite of its large capacity, the operation of the oxygen-producing plant is essentially automatic, once the liquefaction process has been started. The final product, gaseous oxygen, is conveyed through a 16-in. diameter overhead pipeline stretching from the oxygen plant to the smelter, a distance of well over a mile.

* * *

GLASGOW ELECTRICITY BREAKDOWN

Fires in Power Station

During the week-end of February 27-March 1 fires at the 140-MW power station at Dalmarnock in the South West Scotland Division of the British Electricity Authority interrupted the 20-kV supply to parts of Glasgow and the surrounding area. A large number of factories were affected and there was considerable interference with the traffic at both the Central and St. Enoch railway stations.

On Saturday night blast in one of the switch houses, while maintenance was being carried out, resulted in injury to six men and the partial failure of the station supply for about four hours. While the resulting damage was being dealt with a second explosion occurred on Sunday night during the lowering of an oil tank into position, and there was one casualty owing to a fall. This second accident caused an entire interruption of the station supply.

By cutting out the damaged sections of the plant and making use of the grid connections it was, however, possible partially to restore the supply on Monday morning, although a demand of some 110 MW had to be met from other sources. During the day, however, another 20-MW was restored, followed by 56 MW on Wednesday, while by Thursday 70 per cent. of the station's normal putput was available.

The Authority are not yet able to state the causes of the accidents.

Two heat exchangers for the International Nickel Co.'s oxygen-producing plant at Copper Cliff, Ontario, in process of fabrication. Each exchanger contains 400 copper tubes wound in coil form.

60-B.H.P. DIESEL ENGINE FOR COMMERCIAL VEHICLES

Production of the first Diesel engine to be made by the Ford Motor Company, Limited, Dagenham, for use in commercial vehicles, commenced recently. The popularity of the high-speed Diesel engine in this country is still increasing – due presumably to its lower operating costs compared with a petrol engine of similar power output. As can be seen from the illustration herewith, the layout of this new engine follows general practice. It has direct injection, and develops 60 brake-horse-power at a governed speed of 2,400 r.p.m. The maximum torque is 150 lb.-ft. at 1,600 r.p.m. and the torque remains above 140 lb.-ft. between 880 and 2,200 r.p.m.; this should ensure good performance in high gear and minimise the need for using intermediate gears. The engine has been designed to suit their two- and three-ton range of Thames commercial vehicles.

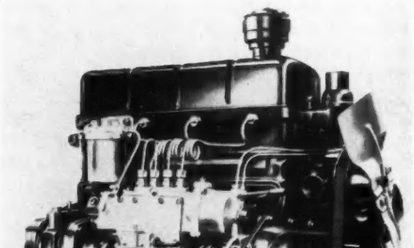
The engines for both the two- and three-ton models are identical but, in the case of the latter, equipment including a sliding-vane type of exhauster, which is mounted behind the fuel pump as can be seen in the illustration, is provided for the servo-assisted brakes.

The engine has four cylinders and a bore and stroke of 3·94 in., and 4·52 in. respectively. The compression ratio is 16 : 1 and the firing order is 1, 2, 4, 3. The cylinder head is fitted with rotating exhaust valves, which prevent the build-up of carbon and the generation of heat. They are said to eliminate any tendency to stick and will prolong the life of the valves by producing an even rate of wear. Cylinder liners of the wet type are used and these can be removed for servicing. The crankshaft, which has induction-hardened main and pin journals, runs in five main bearings of 3 in. diameter. The pistons, which are die-cast in aluminium alloy and tin plated, are fitted with three compression rings and two oil-control rings. The skirts of the pistons are tapered and cam ground. The gudgeon pins, which are fully-floating, are 1·25 in. diameter.

A hydraulic engine stabiliser is fitted between the engine and the chassis frame to absorb the vibration, which is usually more severe with a Diesel engine when idling, and the engine itself is mounted at three points on rubber seatings.

The fuel system includes a Simms pump with a pneumatic governor, feeding to four-hole injector nozzles. The fuel is drawn through a filter, having a glass sediment bowl, by a lift pump and then passed through a micronic-paper filter to the injection pump. The cooling water centrifugal pump is driven by a V-belt from the front of the crankshaft. A thermostatic control is incorporated.

Oil is fed under pressure to the main bearings, connecting-rod bearings and camshaft. A full-flow cartridge-type filter is used and the capacity of the sump is 1·75 gallons.



The new Ford Diesel engine has a maximum torque of 150 lb.-ft. and does not give less than 140 lb.-ft. between 880 and 2,200 r.p.m.

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MEASUREMENT OF HIGH SOURCE IMPEDANCES

Instrument for Research and Works

An instrument, known as the Microvolt Multelec, is being produced by George Kent, Limited, Luton, for use in research establishments and works where high-source impedances are measured. It has been designed to record potentials within a minimum full-scale range of 0 to 100 microvolts with a source impedance up to 50 kilohms, the accuracy being within 0·5 microvolts. This represents a power sensitivity of more than one million times that of a conventional instrument.

As regards construction, the Microvolt Multelec consists of an electronic amplifier for frequencies between 40 and 60 cycles and a recorder with a range of 0 to 100 millivolts. In operation, a direct-current potential from, say, a thermocouple is fed into a filter unit, which is designed to attenuate any alternating-current components, where it is compared with a difference voltage. This voltage is derived from the Multelec through a 1,000-to-1 attenuator, which reduces any "pick-up" errors associated with the measuring circuit to negligible proportions. The difference between these two potentials is passed to a vibrating-reed converter which introduces errors of less than 0·5 microvolts; and the resulting alternating-current potential is magnified in a three-stage resistance-capacity amplifier and fed to the Multelec galvanometer.

The deflection of the needle of the latter instrument is detected by a clamping bar and scissors mechanism, which adjusts the potentiometer output until it is equal to the source potential. Manganin resistors are used in the filter circuit to limit thermal errors. These errors are further decreased by enclosing the circuit in a draught-proof case, which also helps to reduce the effect of stray magnetic fields.

The input impedance of the filter and amplifier alone is 28 kilohms, but at balance an almost infinite impedance is offered to the source that is being measured.

PORTABLE POWER SAW

Lightweight Machine for Bench Use

A portable power-driven hacksaw, which has a capacity of 2 in. by 2 in. square bar and occupies little more bench space than an engineer's vice, has been made by W. Kennedy, Limited, Station Works, West Drayton, Middlesex. Its precision, the makers claim, enables it to cut a slice 0·01 in. in thickness. Contact between the saw blade and work is maintained by a spring, which, in conjunction with a pressure-controlled dashpot, permits the load transmitted by the blade – and hence the cutting speed – to be regulated. Light-gauge tubes and sections may be cut with the same accuracy as solid bar.

The construction of the hacksaw, which is shown in the ilustration below, includes a body die-cast in aluminium alloy, a hardened and ground steel crankshaft and phosphor-bronze lined bearings. The saw-frame, sawing-arm and vice-slide consist of bright-steel hexagon bars, and saw-blades are secured by Allen screw clamps. A Platt's high-speed blade with 24 teeth per inch is fitted, but any kind of high-speed blade up to ½ in. in width, including broken lengths of over 6 in., can be accommodated.

FEED CONTROL BY DASHPOT

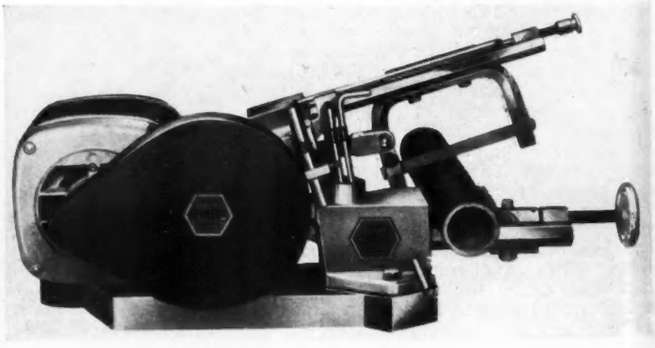
The sawing-arm is lowered on to the work by pressing a spring-loaded knob on the saw-frame and the machine may be safely left to complete the cut without further interference. The perpendicular reaction between the saw blade and the work can be controlled by means of a dashpot which counterbalances the combined load of the saw-arm weight and the spring. This device both limits the tendency to distort thin-walled tubes and enables the feed rate to be varied. To ensure consistent accuracy during repetition work, a depth-gauge and a length-gauge are incorporated in the machine. One hand only is required to set the saw in operation.

The hacksaw plugs into lighting or power circuits and is supplied complete with a ⅛-h.p., 240-volt, split-phase, 50-cycle motor. It is mounted on an aluminium base and is driven through a pulley and a "Miraclo" nylon belt.

It can cut round bar up to 2 in. in diameter, steam and gas pipe of 1¼ in. bore, tube and conduit of not more than 2 in. outside diameter and 2 in. by 2 in. angle. The weight of the complete machine is 40 lb. Its overall length is 22 in., its height 7¼ in. and its width 10 in.

A non-powered version of the hacksaw is made, and fitted with a 4½-in. diameter V-groove pulley for external drive.

Both versions of the machine, the sliding parts of which consist of "Mexlide" units, will be exhibited at the British Industries Fair, Castle Bromwich, Birmingham, to be held during the period May 3 to 14 this year.



Less than 2 ft. in length, this portable power-driven saw incorporates a dashpot relieving device, which reduces the cutting load on the work and enables the feed-rate to be controlled.

BORING AND MILLING MACHINE WITH CO-ORDINATE SETTING

OPERATIONS PRE-SET BY PUNCHED-CARD ATTACHMENT

A machine designed to perform the boring, drilling and milling of components to a high standard of accuracy without the use of any form of jig, and to be pre-set for the succeeding operation during the one in progress, has been built by the Berliner Maschinenbau A.G. (formerly L. Schwartzkopff), Berlin 31, Scheringstrasse 13-28. Known as the Bemag Model KBF-2 co-ordinate boring and milling machine, it can be fitted with an attachment which enables a complete programme of consecutive operations to be pre-selected by means of a punched-card system. In the photograph can be seen the general arrangement of the machine but not the pre-selecting device, which may be incorporated in the lower saddle as additional equipment. An example of this machine, complete with pre-selector unit, will be on display from the middle of May this year in the showrooms of the Rockwell Machine Tool Company, Limited, Welsh Harp, Edgware-road, London, N.W.2, who are the agents for the machine in this country.

Designed to combine rigidity with accessibility, and to facilitate the handling of large workpieces, the machine is of unusual construction in that the saddle, which carries the spindle, slides transversely in a second saddle which itself slides longitudinally on a massive bridge casting above the work-table.

CO-ORDINATE SYSTEM FOR LOCATING SPINDLE

The position taken up by the saddles for a given operation is set in advance with reference to a system of co-ordinates and a predetermined datum, and the pressing of a button begins the cycle. The feeds, which are hydraulically controlled, are steplessly variable and may be pre-set to include in each operation a rapid approach and return. The saddles, together with the table, which is raised and lowered under power, are automatically locked by the hydraulic system when the spindle is set for boring.

The co-ordinate settings are made by rotation of counter wheels, which are arranged in two separate units on the spindle head. These control the setting rods, which are also divided into two groups, one for the transverse and the other for the longitudinal motion.

The digits of the co-ordinate measurements are recorded on dials similar to those of a calculating machine, and in the models produced for measurement in inches there are six digits in each group with the decimal point appearing between the second and third. The final digit increases in steps of 0·0002 in. but the accuracy of the machine is guaranteed only to ± 0·0008 in., although it is claimed that finer settings are possible. The machines with metric scales, such as that illustrated, are constructed to provide readings of five digits and the smallest increment that can be made is 0·01 mm.

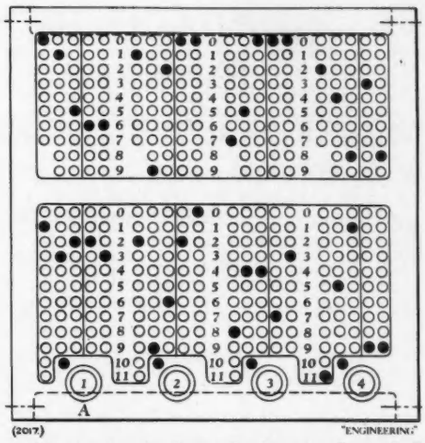
SETTING NEXT OPERATION

During one machining operation, the settings for the next can be made, and not only the co-ordinate location of the spindle in the horizontal plane but also its speed of rotation and rate of feed for boring and milling can be arranged in advance. When the spindle has completed one cut and has been removed from the bore, the succeeding combination of pre-selected measurements is introduced by the pressing of a button. The setting rods are totally enclosed and do not require adjustment by hand.

To simplify control of the machine, the action of the push buttons is interlocked and so prevents the selection of an incorrect movement of saddles or spindle. The possibility of damage is thereby reduced. While the spindle is descending or ascending, for example, there can be no longitudinal or cross motion of the saddles.

The removal of the spindle from a finished bore takes place at increased speed under power. Boring and milling tools are fixed and detached by means of a motor-driven device and can only be exchanged when the spindle is in the correct position. The depth to which boring is to take place can be limited.

In order to reduce the setting time between operations, the machine can be fitted with an attachment which enables a succession of co-ordinate settings to be made directly from a series of punched cards. This is especially convenient when components are to be machined in batches with sequences of operations repeated from time to time. As with the simpler pre-selection device, the pressing of a button, shown at A on the accompanying drawing, introduces a new operation when the previous one is complete. This discontinuity in the cycle is included to permit the exchange of boring heads when holes of different diameter are machined successively.



In this drawing is shown the layout of punched cards for an attachment which enables a programme of operations to be pre-selected. The punched holes represent the digits in a co-ordinate location of the spindle head.

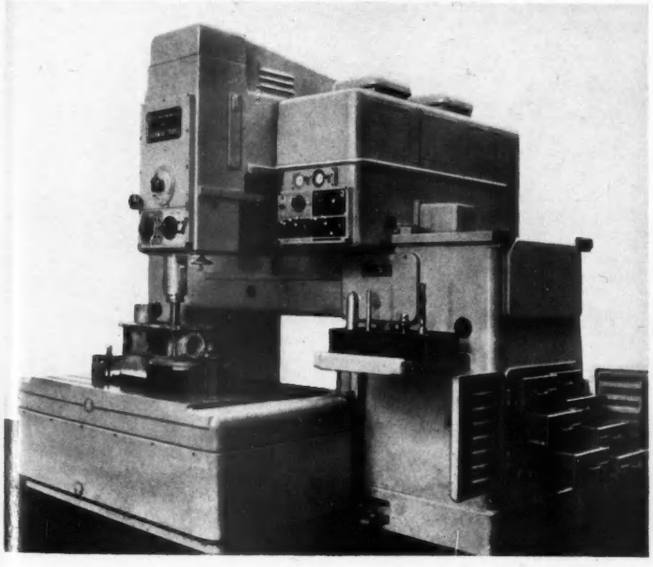
The drawing illustrates the layout of cards used in the metric version of the machine. The upper group of units are concerned with the transverse location of the spindle and the lower with the longitudinal location. The circles shown blackened represent the punched holes and the setting denoted by the first unit of the transverse group is 015·66 mm. and of the longitudinal group is 132·23 mm. The thick lines indicate the decimal points. These two figures give the co-ordinates, with respect to a pre-established datum, of the initial position of the spindle.

The programme of operations is not limited to the four settings shown since an indefinite number of cards can be prepared in a similar way and included in the cycle. The essential components of the device are feeler bars which detect the positions of the punched holes and transmit the information thereby obtained to the setting rods.

The programme pre-selecting mechanism is brought into action by a lever. Signal lamps indicate which of the four units is controlling the cycle at a given time and the lever may be employed to interrupt the programme at any moment to perform a single operation not included in the cycle.

With the punched-card attachment the machine is equally suitable for production in batches or in single items and its design and range of movement enable it to accommodate a large variety of components. The table, which incorporates T-slots, may be raised under power through a distance of 16 in. and for a very large workpiece can be removed entirely; the article is then fixed to the baseplate of the machine.

The range of saddle movements is 47¼ in. in the transverse and 31½ in. in the longitudinal direction and the spindle quill has a vertical travel of 12 in. Feeds up to 4 in. per minute may be selected for milling operations and approach and return motions can be performed at a speed of 157 in. per minute.



A co-ordinate mechanism enables the spindle setting of this boring, milling and drilling machine to be chosen in advance of an operation. Rates of feed for the next operation can also be set during the one in progress.

SURFACE HEATERS FORMED BY SPRAYING PROCESS

ELECTRO-THERMAL DE-ICING SYSTEM FOR AIRCRAFT

A new technique for applying electrical heater elements to surfaces by the use of flame-spray guns has been developed by D. Napier and Son, Limited, Luton Airport, Bedfordshire. In the first place, the process, which is particularly suitable for applying to surfaces of complicated profile and requires only standard commercial equipment, has been evolved specifically for aircraft de-icing installations. It is already fitted on the alternator cooling-air intake on Comet air-liners, and is being fitted on the elevator horn balance and lower part of the fin of Britannia air-liners. Other uses for the system have already arisen in the armament and electronics fields, and it is in fact suitable for many applications in which local surface heating is required – for instance, oil tanks and sumps of internal-combustion engines, and the heating of chemical process vats and containers.

The requirements of a heater mat for ice protection applications are as follows: (1) the heat losses to the structure should be a minimum and the heat transfer to the external surfaces should be a maximum; (2) the resistance of the conductor element should be capable of adjustment in the design stage to give any required power loading at any specified supply voltage over a wide variation of areas; (3) the physical, electrical and mechanical properties of the heater should be subsequently unaffected by temperatures within the range −60 deg. C. to +70 deg. C. and it should be non-inflammable; (4) the external surface finish should be as smooth as possible for aerodynamic reasons; it should also have a high resistance to abrasion and rain erosion; (5) its thickness should be a minimum to avoid undesirable changes to the surface contours and the structure generally; (6) it should be capable of application to any shape of surface including those of compound curvature; (7) good adhesion to metallic surfaces, and to light alloys in particular, is essential; (8) the insulation material should have low water-absorption properties and be impervious to aircraft fuels, oils and hydraulic fluids; (9) it should be possible to carry out local repairs on the heater, if possible in the field; and (10) its weight per unit area should be a minimum.

These requirements led the Napier company to conclude that it is advantageous to form the heater by spraying directly on to the surface to be protected, bearing in mind the normal tolerances possible in sheet metal work and the difficulties of applying a prefabricated mat without entrapping air at the attachment face. This trapped air is liable to cause blistering and overheating when heat is generated by the elements, but a sprayed application of the base insulation ensures intimate contact with the surface.

CONSTRUCTION OF HEATER MAT

Figs. 1 and 2 show the heater mat construction that has been evolved. The base insulation consists of a layer of Araldite, a thermo-setting resin used with a filler and applied in powder form by a flame-spray gun. The electrical conductor consists of copper-alloy or aluminium metal powder, or wire, also applied by a flame-spray gun so as to produce the resistance and pattern demanded by the heat distribution required. It is provided with terminals for connecting to the electrical system. Also of Araldite, the outer insulation is sprayed on and finally finished as a highly polished surface, coloured as desired.

Fig. 3 shows a protected air intake for the Double Mamba engine of the Fairey Gannet aircraft; this is an excellent example of an installation for which it would be extremely difficult to provide surface heating by any other technique. Fig. 4 shows the lower part of the Britannia fin with Napier surface heater mats; the complex curvature of this component, again, renders the spray technique particularly suitable.

MECHANISED SPRAY GUNS

The Napier heater mat may be applied to the surface of suitable shapes by mechanical means, which normally take the form of gun-traversing gear linked by a suitable mechanism to the workpiece turntable in such a way that the rate of pass of the gun across the workpiece can be controlled. The heater element is sprayed in a similar way, the rate of wire feed, the rate of pass and the number of passes being selected from experimentally-determined curves to give the required resistance. Fig. 5 shows a typical mechanised rig in operation. Close control is kept over all spraying conditions to ensure that the desired resistance and degree of uniformity are obtained. In general, objects of single uniform curvature, of aerofoil section, and of spinner section can be treated by mechanical methods.

In both hand spraying and mechanical spraying, the sequence of operations is as follows: the terminals are secured to the surface to be heated by an adhesive and screws. A range of standard terminals of the type illustrated in Fig. 1 is available, to suit the Society of British Aircraft Constructors' system of wiring. The base metal is then cleaned, degreased and abraded to receive the base insulation. The latter is built up to a thickness of the order of 0·03 in. by spraying, each coat being cured at a temperature of 160 deg. to 180 deg. C.

The completed base insulation is then abraded and the metal conducting element is sprayed on. In some cases, the desired conductor pattern is obtained by fixing strips of adhesive tape to the insulation before the metal is sprayed, the tape being stripped off after the spraying is complete. In other cases, particularly where a number of components are to be treated, the metal is sprayed all over the area and is afterwards cut away through a template.

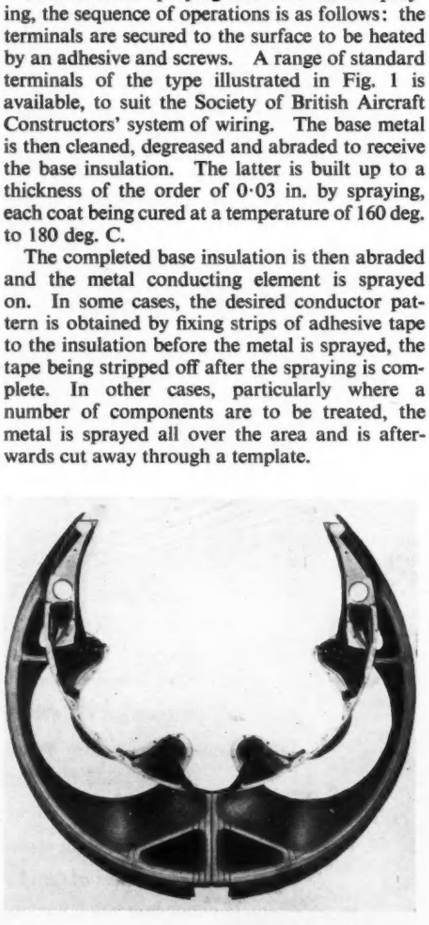
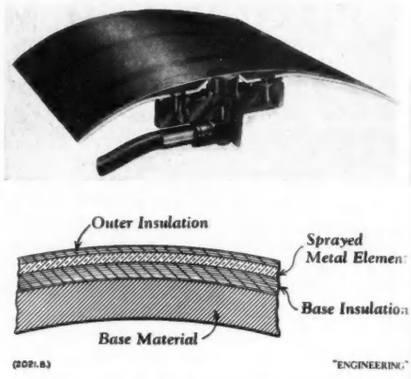


Fig. 3 Napier surface heaters sprayed on to the intake of a Double Mamba engine on the Fairey Gannet aircraft.



Figs. 1 and 2 Construction of the Napier electric heater mat. It is formed by spraying on a base insulation, followed by a metal conducting element, and a top insulating coat. It is resistant to abrasion, water, vibration and fire.

Where the conducting element is hand-sprayed, after the first pass the operator checks for uniformity of coating by checking the resistance over a fixed gauge length with a two-pronged probe. He adjusts the thickness of the coating by rubbing off or spraying on more metal, as required. When the complete conductor has been applied, a high-voltage test of 1,000 volts is carried out to ensure that the base insulation is sound. The top coating of Araldite, usually about one-third of the thickness of the base coating, is then applied, and when complete the heater mat is subjected to functional tests, after which the surface is pigmented or polished as desired. A very light heater mat is thus achieved, its total thickness being 0·04 in. to 0·05 in., depending on the conductor thickness, and its corresponding specific weight being 0·27 lb. to 0·32 lb. per square foot allowing one "miniaturised" terminal per square foot. A high thermal efficiency is achieved although the electrical insulation material is also a good heat insulator.

PROVING TESTS

The Napier heater has been extensively tested and has shown itself to fulfil the specified requirements to a very high degree. It has successfully undergone a type test approved by the Ministry of Supply, consisting of climatic, vibration, elec-

Fig. 4 Surface heaters on the fin of a Bristol Britannia aircraft.

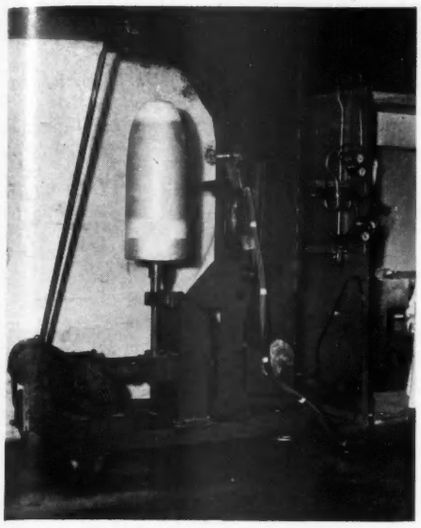


Fig. 5 Spray gun mechanically traversed by following a cam conforming to the shape of the workpiece being sprayed.

trical insulation and inflammability tests. Other tests include powered endurance tests in which 1,000 hours of cyclic operation at 10 watts per square inch with water cooling, and 1,000 hours continuous and 1,000 hours cyclic operation at a surface temperature of + 70 deg. C. have been successfully achieved. With cold-air wind-tunnel cooling, power loadings of 40 watts per square inch have also been maintained without failure. The heater has proved to be unaffected by all aircraft fuels, oils and hydraulic fluids, and flexural fatigue tests have been carried out with mats mounted on resonant bars. During these tests, at the severe condition of a strain at the surface of the mat of ± 0·176 per cent., at which the surface stress in the bar was ±15,000 lb. per square inch, the element failed at 4·1 million cycles ; 48 million cycles were achieved without failure at a surface strain of ± 0·153 per cent. Type tests, consisting of full power tests, tests at + 70 deg. C. and electrical insulation tests, are also carried out on at least one sample of any specific installation.

The maximum operating temperature for the Napier mat is at present fixed at 100 deg. C. It is normally advisable to instal some form of overheat protection to safeguard the heater against such contengencies as emerging from icing conditions into dry air, and in ground testing, although for the latter purpose it is sometimes sufficient to impose limits on the time of operation or to specify reduced voltages for test purposes. A thermal cut-out unit utilising a resistance sensing element has been developed by Teddington Controls Limited, Merthyr Tydfil, for this purpose; this firm have also developed a cyclic switch for use with the system.

The resistance of the Napier heater mat to sand abrasion has been proved by tests on York, Tempest and Canberra aircraft, including considerable service in tropical conditions. The rain erosion properties of the standard insulation have also been established by flight tests in rain by a Venom aircraft. For high-speed applications a modified resin (pigmented if required) is used for the outer layer, which accelerated tests have shown to have superior erosion properties. For yet higher speeds, the application of a metal protective layer can be adopted, and the Napier company are using a whirling-arm test rig to assist in its further development.

INSPECTION, MAINTENANCE AND REPAIR

A visual examination is all that is normally required during inspection of heaters in service. Any region showing evidence of mechanical damage should be investigated further by insulation and resistance checks employing normal servicing equipment. Where a full ground functioning test is deemed desirable, such a test would be carried out at reduced voltage using a power-supply pack available from the Napier company.

An important advantage of the Napier heater-mat construction is the ease with which electrical repairs may be carried out, should they ultimately become necessary, using hand-spraying methods. The damaged section must be removed if necessary, right down to the base metal, and the base insulation replaced by building up with synthetic resin. A new section of heater element is then grafted in by spraying, checked for uniformity, and the top insulation applied.

APPLICATIONS TO AIRCRAFT DE-ICING SYSTEMS

In Fig. 6 is shown the modified Viking de-icing research aircraft used, in conjunction with refrigerated wind-tunnel investigations, in developing the Napier heater-mat system. The test heater mats can be seen mounted on the leading edge of the fin, forward of which is a water-spray mast for producing artificial icing conditions. An auxiliary power unit installed in the cabin drives two 30-kW alternators supplying electrical power for the heater mats. On aerofoil surfaces in which the air stream can be used to assist in shedding the ice, a cyclic system is employed, by which ice is allowed to form and is shed periodically before it builds up too seriously. Thus, the surface is divided into a number of areas, each of which is heated in turn ; to destroy the adhesion of the ice a continuously-heated parting strip is fitted along the leading edge and chordwise continuously-heated parting strips are provided to ensure clean shedding of each area.

In the case of engine or alternator cooling-air intakes, etc., ice must not be allowed to form and all the super-cooled water droplets impinging on the intake must be completely evaporated. Continuous heating is therefore employed in such cases. In Table I is given a summary of the electrical loads of a typical electro-thermal protection system for a hypothetical four-engine turbo-propeller transport aircraft with an all-up weight of 120,000 lb., a span of 130 ft., and a cruising speed of 350 m.p.h. at 20,000 ft. The main planes, tail units and propellers are provided with a cyclic heating system with a ratio of " heat on " to " heat off " of 1 to 10. The engine intakes and propeller spinners are continuously heated, but in the latter case it is not necessary to evaporate the water droplets completely. The weight of such an installation is estimated at 1,064 lb., which is 0·89 per cent. of the all-up weight.

TABLE I. *Summary of Loads for Electro-Thermal Protection for a Typical Four-Engined Turbo-Prop Transport Aircraft.*

Component	Power Input		Remarks
	Continuous kW	Cyclic kW	
Wings	26·5	10 × 32·8	Assuming no protection inboard of inboard nacelles
Tailplane and fin	18·5	6 × 15·8	Cycled with propellers
Propellers ..	—	4 × 12·0	Cycled with tail unit
Four engine intakes	28·0	—	Dry Anti-icing
Four spinners ..	12·0	—	Wet Anti-icing
	85·0	48·6	
	Maximum total input 133·6 kW		

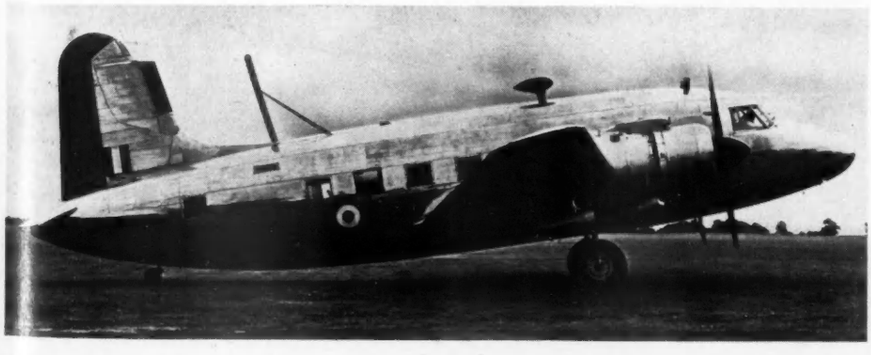


Fig. 6 Viking de-icing research aircraft, showing the Napier test de-icer mounted on the fin and a spray mast for producing artificial icing conditions.

* * *

JOINTS IN WATER-RETAINING STRUCTURES

The Rubber Water-Stop

An essentially practical paper, entitled " Joints in Water-Retaining Structures " was presented before the Institution of Sanitary Engineers at a meeting held in London on March 11. The author was Mr. P. L. Critchell, technical service officer to Expandite, Limited, Willesden, London, N.W.10, and a sound-film in colour illustrated not only how various types of joints in concrete should be made, but also the troubles which followed when unsuitable joints were provided. The film also showed certain specialised machines being used for cleaning and refilling joints on airfield runways. Mr. E. H. Vick, M.I.C.E., the President, was in the chair.

The author stated that it was necessary " to consider each part of the structure separately so that jointing materials in conjunction with the joint design are selected to suit the particular conditions obtaining in that part " and during the discussion the necessity of having suitable joints was stressed since, as one speaker said, a leakage in a reservoir could lead to the loss of much valuable water and repairs were expensive.

During the discussion the question was raised as to whether the use of rubber as a water-stop was to be considered as a substitute for copper sheet or as something which was as good or better. In his reply the author pointed out that the bulbous edges of the rubber water-stop enabled it to be gripped more firmly as the concrete contracted, so improving its sealing properties. He said the rubber water-stop first came into use in the United States in 1936 at a time when there was no shortage of copper, and he referred to its ability to withstand a considerable differential settlement of adjacent concrete slabs, a demonstration of which was given in the film shown.

RUNNING PROTECTION FOR DIESEL ENGINES AND COMPRESSORS

Instruments for Automatic Control

Three instruments for the protection of unattended Diesel engines used for driving generators or other plant were recently added to the range of engine-control equipment made by Teddington Industrial Equipment, Limited, Windmill-road, Sunbury-on-Thames, Middlesex. They are a pressure-controlled unit for Diesel-powered air compressors; an oil-pressure failure device; and an engine safety switch.

The first of these is designed to protect Diesel-driven compressors against a failure of lubricating-oil pressure in either the engine or compressor and against excessive intercooler pressure. It will withstand the arduous conditions associated with mobile road-drilling machinery and it does not require an electricity supply.

Capillary tubing is used to connect three pressure-sensitive elements incorporated in this instrument to the engine and compressor. In the event of the oil pressure in either the engine or compressor falling below, or the intercooler pressure rising above, a pre-set figure the pressure-sensitive element operates a valve incorporated in the instrument, which in turn directs air, taken under pressure from the compressor receiver, to a pneumatic piston control attached to the fuel pump of the Diesel engine. This valve cuts off the fuel supply.

All three elements used in the instrument can be adjusted to suit particular requirements, and there is a manual reset lever which must be held down when starting until the normal operating pressures have built up in the control circuit.

The second instrument in its standard form is a single-purpose unit for protection against oil-pressure failure, but it can be used, alternatively, to protect the engine against an excessive coolant temperature. Designed for mounting on the engine adjacent to the throttle, it has a spring-loaded operating lever, connected to the throttle by a rod or link arm, that returns to the throttle-closed position when free to move. In use, this lever is held in the throttle-open position by a spring-loaded latch. The operating element is a bellows unit, sensitive to pressure, which can be adjusted for the normal range of oil pressures. Should the lubricating-oil pressure of the engine fall below a fixed value the bellows unit releases the latch and the lever returns the throttle to the closed position, shutting down the engine.

The third instrument is a dual-purpose control designed to operate either a visual or audible alarm and it can be used with any one of many standard solenoid-operated shut-down instruments made by the same company. Although intended for use with Diesel engines it can also be made with switches arranged to earth the spark-ignition circuit of petrol engines.

The standard instrument is sensitive to lubricating-oil pressure and to coolant temperature. Other models are made with elements responsive to coolant temperature and oil temperature or with three elements responsive to oil pressure, coolant temperature and oil temperature.

A special feature of the design is the provision of a simple control knob which puts the oil-pressure switch out of action while the engine is being started. When the engine is up to normal speed the control is switched over to the " auto " protected position. Temperature changes are recorded by means of a sheathed thermocouple and the instrument can be adjusted to any pressure or temperature likely to be encountered in normal engine practice.

STAND-BY DIESEL GENERATOR FOR AIRPORT

A 55-kW Diesel-electric generator is to be installed at the Kano airport in Nigeria to act as a stand-by in the event of failure of the mains supply. It is fitted with automatic control equipment which will start the engine when necessary and shut it down when the mains supply is restored. It will also provide full protection from faults while the set is running.

The machine, which is shown in the accompanying illustration, consists of a four-cylinder airless-injection radiator-cooled engine with an output of 88 brake horse-power at 1,000 r.p.m. It was manufactured by J. and H. McLaren, Limited, Leeds, and is connected through a flexible coupling to a 55-kW Brush alternator of the drip-proof screen-protected salient-pole revolving-field type, which generates three-phase current at 400 volts and 50 cycles. Excitation is provided by a belt-driven exciter and control is effected from a sheet-steel switchboard made by the Brush Electrical Engineering Company, Limited, Loughborough, on which the instruments, synchronising lamps and a carbon-pile voltage regulator are mounted. This board, as well as the radiator and fuel tank, are mounted on the same steel fabricated bedplate as the engine and alternator, while, as shown in the illustration, the automatic control equipment is housed in a separate cubicle.

This cubicle contains a selector switch which enables the engine to be started or stopped by local push-button when it is in the " hand " position. When, however, it is in the " automatic " position, the engine is started when a phase or phases of the mains supply fail. After a short interval contactors close so that the alternator takes the load by the operation of a centrifugal switch. When the supply is resumed on all phases the various contactors open, so that the load is returned to the mains and the engine is shut down. Electrical and mechanical interlocks are fitted so that the alternator cannot be coupled to the mains. If the engine fails to start after a pre-determined time the " start " signal is cancelled and audible and visual alarms are given.

PRIMING PUMP RUN EVERY FOUR HOURS

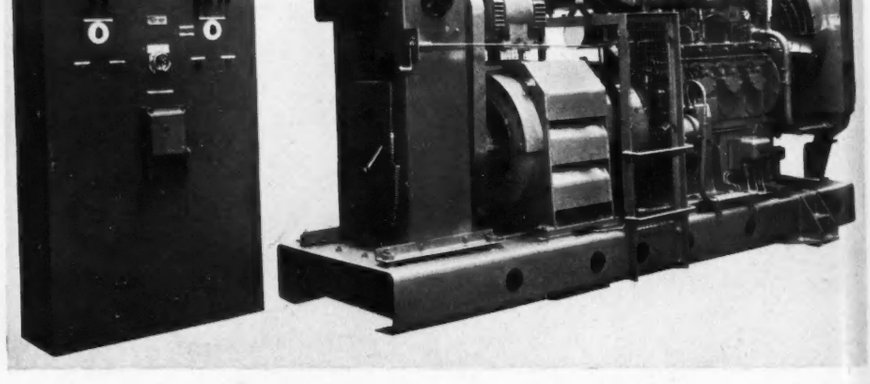
Power for starting is obtained from a 24-volt battery which is trickle-charged from the mains through a transformer and metal rectifier. An electrically-driven priming pump with a relief by-pass and time switch, which is operated from the mains, is another auxiliary which is run for a fixed period every four hours to ensure that the engine is always fully primed with lubricating oil. In addition, there is a thermostatically-controlled heater in the cooling-water circuit of the engine to ensure that the set is maintained at a reasonable temperature when not running.

PROTECTION WHILE RUNNING

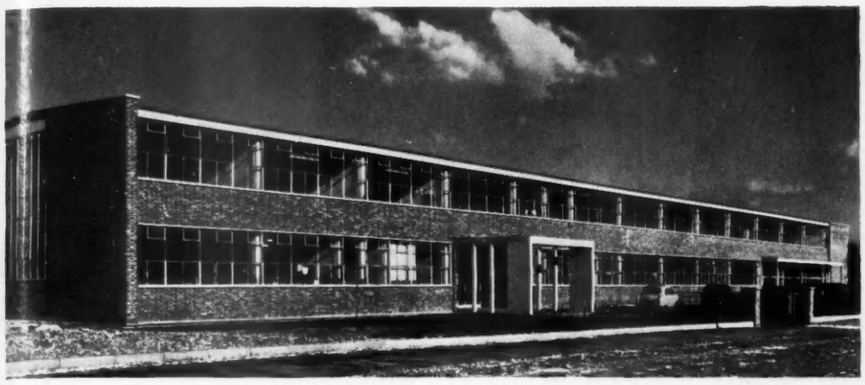
While running, the engine is protected from low lubricating-oil pressure and excessive cooling-water temperature by a series of relays which close the circuit of a solenoid. This solenoid, which is energised from the battery, actuates the fuel-pump rack and shuts down the set. A time delay is fitted which automatically releases the solenoid, and thus the fuel-pump rack, after the engine has stopped, so that it is ready for re-starting. The relays also illuminate the appropriate lamps on the control panel and ring alarm bells. Another relay, which is actuated by a float-switch in the tank, indicates that the fuel reserve is low by giving an audible and visual alarm, but does not shut down the engine.

STARTER DESIGN

Although the electric starter is in this case supplied from a battery, two synchronous motors fed from the mains could be used and could be arranged to work against full compression. Alternatively, a single motor could be employed in combination with a solenoid for operating half-compression valve lifters. The starter motor itself is of the axial type, that is, the armature can be moved axially in its bearings so that a pinion on its shaft engages with teeth on the rim of the flywheel. It is held in the disengaged position by a spring, which is enclosed in its shaft at the commutator end. When hand starting is employed the pinion is held in mesh with the flywheel teeth by a winding which remains in circuit until the starter button is released. When starting automatically, however, the starter circuit is broken by a small centrifugal switch when a speed of about 400 r.p.m. has been reached.



55-kW Diesel-electric generating set which is to be installed at Kano airport, Nigeria, as a stand-by source of electricity supply in the event of mains failure.



Front view of the Allendale Works. The canteen is on the extreme right and above it the general office; the research laboratory is on the left.

FACTORY IN A NEW TOWN

MAKERS OF HIGH-VACUUM EQUIPMENT MOVE THEIR WORKS

On March 5, the new factory of W. Edwards and Company (London), Limited, at Manor Royal, Crawley, Sussex, was officially opened by Sir Ben Lockspeiser, secretary of the Department of Scientific and Industrial Research. It is called the Allendale Works, to commemorate the original premises which were in Allendale-road in South-East London. The site covers 11 acres, the floor area of the buildings being 100,000 sq. ft., of which about 15,000 are occupied by administration offices. The illustration shows the front of the building which faces south; the canteen, with accommodation for 250, is on the extreme right and over it is the general office. The latter extends for half the length of the building, without fixed interior partitions; a false ceiling has been fitted to reduce noise, and the floor is laid with cork squares for the same reason. There is provision for movable partitions to suit changing requirements.

ARRANGED FOR WORK FLOW

The high-vacuum equipment manufactured by the company lends itself to batch production so that flow lines for the work need not be rigidly followed. This allows rather more freedom in the choice of layout and also for future changes. A single overhead crane serves both receiving and dispatching bays, while between them is the main assembly shop; the raw materials store is opposite the former bay, and the packing shop is adjacent to the latter. Throughout the factory care has been taken to reduce the number of roof supports so that the working space is kept as clear as possible; how well this object has been attained can be seen in the general view of the machine shop. The north lights and fluorescent lighting can also be seen in this illustration.

PROVISION FOR RESEARCH

Nearly a quarter of the floor area is devoted to research and development for in this specialised work fresh applications are always being found. Also, much of the equipment has to be individually designed and made which would interrupt the flow of the main shops. In addition, plant is developed to customers' requirements. The vacuum coating of items with metals or lacquer is one of the more recent developments and, in particular, the coating of tissue paper with zinc for the manufacture of condensers. Machines have been evolved which will produce continuous strips of the coated tissue. Freeze-drying, which plays a large part in the preparation and preservation of blood plasma, penicillin and other pharmaceuticals, is another side on which research continues. The layout is arranged so that no part of the research section is more than 20 ft. from a grid carrying electricity, gas, water and compressed-air supplies.

TEST AND DISPATCH

When working with high vacua, even the smallest leak becomes intolerable, and therefore there is a special section which examines all products for leakage. This is done by evacuating the item to be tested while in an atmosphere of hydrogen and detecting the presence of the latter with a heated palladium grid. All parts of the equipment are tested in this way before final assembly. There is also a test and inspection section where the performance of equipment is checked (under tropical conditions if need be) before dispatch. Articles to be dispatched abroad are " cocooned " in plastic before being crated in order to preserve them during transit; three layers are used and a little silica-gel is enclosed. No observation window is fitted unless it is known that the shipment may be left packed for more than about a year.

About 500 people are employed at the new factory, which takes the place of the previous one at Lower Sydenham. The new buildings were designed by Mr. H. W. Moore, F.R.I.B.A., in conjunction with the chief architect of the Crawley Development Corporation, which body was also the sponsor. James Longley and Company, Limited, Crawley, were the main contractors.

Machine shop, showing the clear working spaces and fluorescent lighting.

* * *

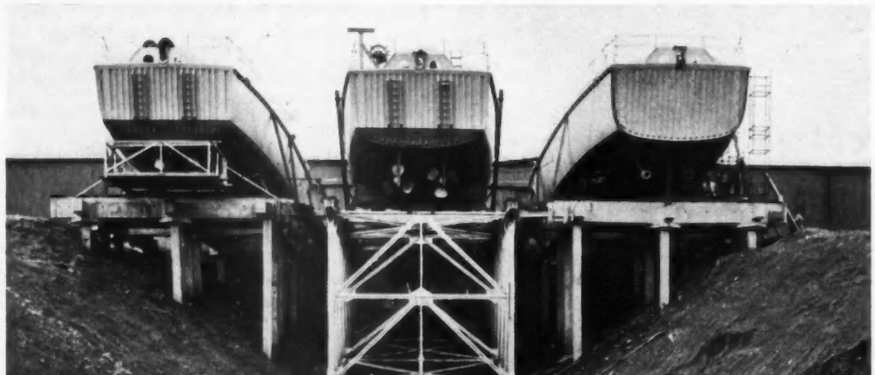
HIGH-PURITY METALS

Applications for Mission to United States Invited

The Department of Scientific and Industrial Research have informed us that the European Productivity Agency of the Organisation for European Economic Co-operation (O.E.E.C.) are organising a mission to the United States to study the manufacture and use of high-purity metals. The mission will give special attention to barium, beryllium, germanium, titanium, tungsten, molybdenum, manganese, nickel, cobalt, selenium, tantalum and zirconium. The field of application of these metals is rapidly widening and improved production techniques are needed. It is added that, in Europe, the development of processes for the economic production of some, at all events, of these materials is well behind that of the United States, where their scale of application is also much larger than it is on this side of the Atlantic.

The attention of the mission will be focused on the manufacture of compounds or concentrates for the production of the pure metals listed above and their preparation by various other available methods. Analytical processes, testing techniques, the investigation of impurities and the processing of the pure metals and their alloys, and their application, will also be studied.

It is proposed that the United Kingdom be represented on the mission, but it is not yet known how many places will be available. The programme of visits of the mission will last approximately four weeks, with a tentative starting date towards the end of June. The cost to each delegate will be about £300, and firms or individuals interested in the mission should address their inquiries to the Board of Trade, IM2 Division, Horse Guards-avenue, Whitehall, London, S.W.1. (Telephone: TRAfalgar 8855, extension 2740 or 2741.)

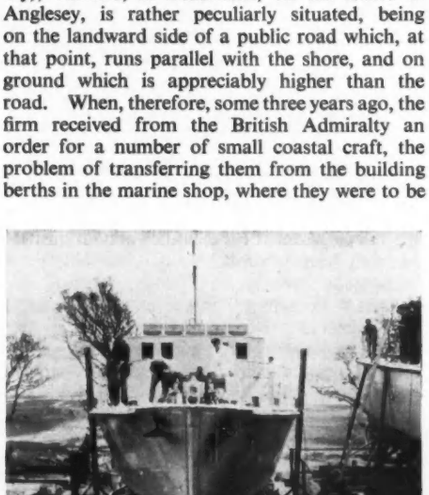


Three auxiliary minesweepers under construction on the shuttle carriage and hard standings.

25-ton winch, which controls the movement of the shuttle carriage.

LAUNCHING SLIPWAY FOR SMALL CRAFT

The shipyard of Messrs. Saunders-Roe (Anglesey), Limited, at Beaumaris, on the island of Anglesey, is rather peculiarly situated, being on the landward side of a public road which, at that point, runs parallel with the shore, and on ground which is appreciably higher than the road. When, therefore, some three years ago, the firm received from the British Admiralty an order for a number of small coastal craft, the problem of transferring them from the building berths in the marine shop, where they were to be constructed under cover, to the water, presented some difficulty, as the shop is 42 ft. above sea level and about 900 ft. from the water. The existing slipway, built during the war for the handling of flying boats, was not suitable for the purpose and had the further disadvantage of being about 200 yards farther away from the erecting shop.



The shuttle carriage moving down to the roadway for launching the vessel.

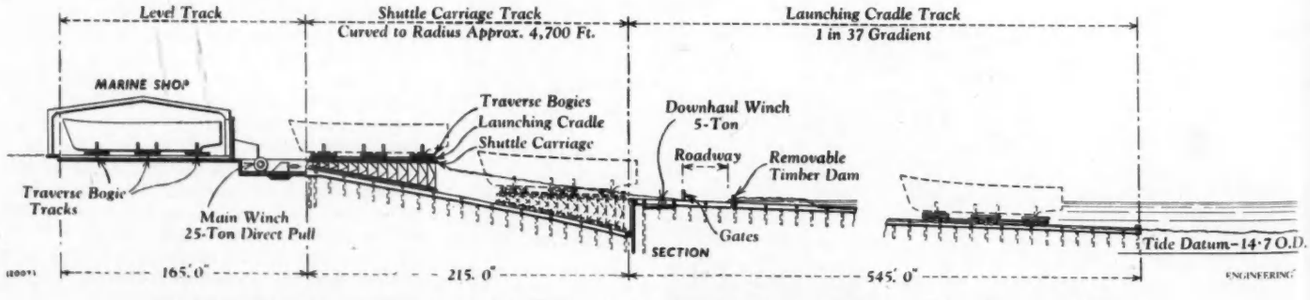
The weight of the craft to be built was too great to be carried on two axles, which made it impracticable to use a slipway having any sudden change of gradient; and the idea, at first contemplated, of constructing a slipway having a uniform radius in a vertical plane, starting from the level floor of the shop, and using on it a carriage with multiple axles disposed on a corresponding uniform radius, had to be abandoned because it would have involved so steep an angle of entry into the water that there would be insufficient depth for launching.

The solution eventually adopted combines the useful features of those previously discussed while avoiding the drawbacks mentioned above. The slipway is divided into three portions, namely, a level track 165 ft. long, extending from within the erecting shop to an open space outside; then a length (in plan) of 215 ft., constructed to a vertical radius of 4,700 ft.; and a final length of 545 ft., set at a uniform gradient of 1 in 37, the lower end of which extends into the water. A shuttle carriage of lattice construction runs on the central portion and, when at the lower end of it, is flush with the level of the public road.

The craft are built on parallel berths in the erecting shop and, when ready for launching, are moved sideways on traversing rail bogies on to a travelling cradle, also on wheels, which is then lowered down the slipway on to the platform of the shuttle carriage. Under the control of an electric winch, capable of exerting a pull of 25 tons, the shuttle carriage, in turn, is then lowered down the central portion of the slipway. When the carriage has reached the limit of its travel, the cradle is transferred from it to the level crossing over the road and thence is lowered on to the final incline, extending into the water, where the vessel floats off.

At the head of the central incline, immediately outside the shop, two "hard standings" have been prepared, one on each side of the track. By the use in conjunction of the traversing bogies and the travelling cradle, hulls can be transferred from the shop to these hard standings for fitting out, thus releasing two berths within the shop for further new construction. At the foot of the central incline, and between it and the road, there is a pit containing a downhaul winch, capable of exerting a pull of 5 tons. The slipway, shuttle carriage, etc., have been designed to deal with vessels weighing up to 300 tons; and the layout is such that it will be possible to construct further hard standings and thus to increase the number and size of the craft that can be under construction at one time.

The consulting engineers for the complete scheme were Messrs. Maunsell, Posford and Pavry, of Westminster, S.W.1, and the contractors were Messrs. Pochins (Manchester), Limited.



Drawing showing the arrangement of the slipway which enables craft to be brought down to the sea for launching.

Labour Notes

MODEL RULES FOR ARBITRATION IN INDUSTRIAL DISPUTES

An assurance that the Government had no desire whatever to sponsor the introduction of procedure which would lead to the dictation of a wage policy, or conditions of employment, was given by Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour and National Service, in a speech at the opening of a conference on " The Human Factor in Industry " at Buxton on March 11. Their policy, he said, was to strengthen the negotiating machinery in industry in such a way that strikes would be rendered unnecessary.

In his opinion, both sides of industry would eventually come to realise that strikes and lock-outs were outmoded weapons. At the same time, it should remain the clear right of every union and every employer to have recourse to these drastic courses of action, should they feel that there was no other means of obtaining justice.

Strikes and lock-outs could be made unnecessary by devising a sound system of negotiation and arbitration, so that justice was done and, equally important, seen to be done. There must be finality in dealing with all industrial disputes. If a disagreement could not be settled locally, there should be a recognised procedure for bringing it to the national level. If the difficulty could not then be settled by negotiation, it should be referred automatically to some form of arbitration.

The form of arbitration chosen could be that set up by the industry concerned, and based, perhaps, on a model constitution drawn up by the Ministry of Labour, or it could be arbitration by the Industrial Disputes Tribunal, or by a body set up in accordance with the provisions of the Industrial Courts Act.

There was a gap in the structure of industrial negotiation, caused by the difficulty of trying to relate the national interest to particular industrial problems. Although the Government would not interfere, they had to give a lead to management and employers.

What was wanted most was a period of stability in respect of employment, wages, prices, and the cost of living. Industrial peace was not enough. There must be good relations and teamwork. Provided no abnormal trends developed in world trade, increased pay should be the reward for efficiency and higher production.

REACTION OF TRADES UNION CONGRESS TO WAGE-POLICY PROPOSALS

Sir Walter Monckton, the Minister of Labour, has now received replies to his invitations to the British Employers' Confederation, the Trades Union Congress, and the Boards of the nationalised industries to discuss with him proposals for preserving good relations in industry. It has now been arranged that the Minister will have separate conferences with representatives of each of these organisations, but there appears to be good reason for believing that joint discussions will follow.

Sir Walter's invitation arose from suggestions in the reports of the courts of inquiry into the engineering and shipbuilding wage disputes that an authoritative and impartial body should be set up to give advice and guidance on the general problems involved in large-scale wage demands.

The principal aim of the talks with Sir Walter will be, presumably, to consider the broad field of labour questions in relation to the national economy, with a view to determining whether the establishment of such a body as that envisaged by the courts of inquiry is feasible at the present time. Collective bargaining, wages, profits, prices, and costs are all likely to be discussed, but the need for strengthening and extending voluntary arbitration may well be the main topic.

At their regular meeting on March 10, the economic committee of the T.U.C. discussed Sir Walter's invitation and decided to accept his proposals for a meeting, but without committing themselves to any particular point of view. The suggestions of the courts of inquiry were of a general nature only and it seems that the committee wish to know more precisely what Sir Walter has in mind before deciding their own attitude.

With respect to arbitration, the general feeling of the committee appears to be that this subject should be considered quite independently of the question whether a new body should be formed to advise on wages.

MINERS' STRIKE OVER STINT REQUIREMENTS

Some intensification of strikes in the coal-mining industry took place at the end of last week. On March 11, it was announced that the afternoon shift at Grimethorpe Colliery had ceased work in support of the stoppage at Hatfield Main Colliery, near Doncaster, where some 2,700 miners went on strike on March 9, owing to dispute over the stint allotted to fillers. Earlier, some 300 fillers at Hatfield had been refused work by the management for declining to discontinue alleged go-slow practices. The men concerned protested that they had been working normally and that the pit managers had given them tasks in excess of those laid down in their working agreement.

In spite of urgent pleas by the strikers, the National Union of Mineworkers refused to recognise the dispute and local officials of the union urged the men to return to work, in order that their grievances might be investigated.

At a mass meeting of Hatfield colliers on Sunday, which was addressed by the union's area officials, the men agreed to resume work on the following day. They passed unanimously a resolution stating that they did so in accordance with the understanding, which had been reached between the union's area officials and representatives of the National Coal Board, that their daily task should not be greater than that laid down in the industry's charter and defined by the local branch of the union in its resolution of February 23 last.

Both sides have arranged to investigate the question of what constitutes a fair day's work, as set out in existing agreements. The strike at Hatfield lasted five days and resulted in the loss of over 12,000 tons of coal. A local union official, commenting on the strike, paid a tribute to Mr. W. H. Sales, labour director to the Coal Board, for his action in personally visiting the colliery, in his efforts to settle the dispute. The official suggested that understanding conduct of that kind did an enormous amount of good throughout the industry.

SYMPATHETIC STRIKES AT GRIMETHORPE AND SOUTH SHIELDS PITS

With respect to the stoppage in sympathy, undertaken by employees at Grimethorpe Colliery, it may be recalled that Hatfield miners were among the first to go to the assistance of the Grimethorpe men during their dispute over alleged large stints in 1947. When a similar dispute arose at Hatfield, a feeling appeared to exist at Grimethorpe that the men there should repay that support.

The strike at pits in the South Shields area continues. The trouble started at Whitburn Colliery on February 26, when miners at the colliery ceased work on account of what they claimed to be the " tyrannical " attitude of a fore-overman.

On March 8, colliers at Harton and Westoe pits in the South Shields area withdrew their labour in support of the men at Whitburn. This left only the Boldon Colliery, in the South Shields group, still functioning.

During the week-end, telegrams were sent by Sir Will Lawther, President of the N.U.M., to the local miners' lodges urging the men to return to work immediately. He said that it would be wrong to condemn the overman concerned before a fair investigation had taken place.

Men at the Boldon Colliery were ordered by the South Shields area committee of the Mineworkers' Federation Board, on March 12, to join in the strike action or, alternatively, to leave the Federation.

ELECTRICIANS' WAGE CLAIMS

After two months of isolated strike action in various parts of the country, operatives in the electrical-contracting industry resumed work on March 12. An offer of an increase of 2*d.* an hour, equivalent to 7*s.* 4*d.* a week, was accepted by the men's union, the Electrical Trades Union, on the previous day. Proportionate amounts will be paid to adult mates and apprentices. These increases were due to take effect as from last Monday, and a total of some 45,000 employees in the industry are expected to benefit.

When the claim was originally presented about a year ago, the union asked for a " substantial increase," and it was generally understood that advances of 3*d.* an hour for men in the London area, and 2½*d.* an hour for men employed elsewhere, was expected.

It was part of the agreement that there should be an early meeting of the National Joint Council for the Electrical Contracting Industry to consider a further advance in wages. This took place last Friday and was adjourned until Monday. On both occasions, the employers' representatives stated that they had not had sufficient time to consider the matter.

MERGER PROPOSALS OF PRINTING TRADE UNIONS

Reports on the progress of negotiations for the amalgamation of the Printing Machine Managers' Trade Society and the London Society of Compositors during the present year, are contained in the March issue of the *London Typographical Journal*, the Society's official periodical.

Proposals that discussions on the merger should begin at an early date were approved recently at separate meetings of representatives of each of the two unions. In both cases, it was a condition of the delegates' approval that the equal status of each body should be recognised and respected. A joint committee is understood to be preparing a draft constitution and by-laws for the proposed new organisation.

About two years ago suggestions were put forward for the amalgamation of the Printing Machine Managers' Trade Society with the National Society of Operative Printers and Assistants, the largest of the unions in the printing trade, but no progress was made. More recently, the latter union suggested that the negotiations between the two bodies should be resumed, and that the Typographical Association should be invited to join in the merger.

These proposals also appear to have fallen through, but there seems to be a possibility that the National Society of Operative Printers and Assistants and the Typographical Association may continue their discussions separately.

NOTICES OF MEETINGS

British Institution of Radio Engineers

WOLVERHAMPTON
"Industrial Application of Electronic Instruments," by A. G. Wray. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Tues., Mar. 23, 7.15 p.m.

Chemical Society

LONDON
"Organo-Metallic Compounds Containing Fluoro-Carbon Radicals," by Professor H. J. Emeléus. Thurs., Mar. 25, 7.30 p.m.

Illuminating Engineering Society

LONDON
Short papers on "New Lighting Installations." Lighting Service Bureau, 2 Savoy-hill, W.C.2. Tues., Mar. 23, 6 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Industrial Electrical Maintenance," by D. Parkes. Annual General Meeting. Imperial Hotel, Birmingham. Fri., Mar. 26, 7.30 p.m.
BLACKBURN
Annual General Meeting. Grosvenor Hotel, Blackburn. Wed., Mar. 24, 7.30 p.m.
SHEFFIELD
Annual General Meeting. Grand Hotel, Sheffield. Thurs., Mar. 25, 7.30 p.m.

Institute of British Foundrymen

BIRMINGHAM
"Use of Synthetic Resins in Core Bonding," by W. Andrews. James Watt Memorial Institute, Birmingham. Wed., Mar. 24, 7.15 p.m.
SLOUGH
Discussion on "Zinc Die Casting." Offices of High Duty Alloys, Ltd., Slough. Tues., Mar. 23, 7.30 p.m.

Institute of Fuel

LONDON
"Solar Energy for Water and Space Heating," by Dr. H. Heywood. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Tues., Mar. 23, 5.30 p.m.
BIRMINGHAM
"Problems of Boiler-Water Treatment at Medium and High Pressures," by C. W. Drane. Midland Section. James Watt Memorial Institute, Birmingham. Thurs., Mar. 25, 6 p.m.
LIVERPOOL
Annual General Meeting. Various short papers by members. North-Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Thurs., Mar. 25, 7 p.m.

Institute of Industrial Supervisors

GLASGOW
"The Foreman and Factory Costs," by J. Loudon. Royal Technical College, Glasgow. Thurs., Mar. 25, 7.30 p.m.

Institute of Marine Engineers

LONDON
Film on "Lubrication," presented by J. L. Heaton. Junior Section. Mon., Mar. 22, 6.30 p.m.
Annual General Meeting. Tues., Mar. 23, 5.30 p.m.
DAGENHAM
"Gas Turbines," by J. C. Grey. Junior Section. South-East Essex Technical College, Dagenham, Essex. Wed., Mar. 24, 7.30 p.m.
EDINBURGH
"A Talk on the Denny-Brown Ship Stabiliser," by Sir William Wallace. Scottish Section. North British Hotel, Princes-street, Edinburgh. Wed., Mar. 24, 7.30 p.m.
SUNDERLAND
"The Heart of a Tanker," by H. Nicol. North-East Coast Section. The Technical College, Sunderland. Thurs., Mar. 25, 7 p.m.

Institute of Road Transport Engineers

HEATHFIELD
"Plastics and Their Use in the Road Transport Industry," by A. Jones. South Wales Group. Municipal Employees' Club, Highcliffe, Heathfield, Devonshire. Fri., Mar. 26, 7 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of Rama VI, Surat, and Bandara Bridges in Thailand," by O. A. Kerensky and K. E. Hyatt. Works Construction Division. Tues., Mar. 23, 5.30 p.m.
CHESTER
"The New Iron-Making and Steel-Making Plant at Shotton, near Chester," by J. F. R. Jones. North-Western Association. The Council Chambers, Chester. Fri., Mar. 26, 7.30 p.m.
HULL
"Jetties and Fenders," by Professor A. L. L. Baker. Yorkshire Association. Electricity Show Rooms, Ferensway, Hull. Fri., Mar. 26, 6.15 p.m.
NOTTINGHAM
"East Coast Floods," by J. Finn. Midlands Association. East Midlands Gas Board's Show Rooms, Lower Parliament-street, Nottingham. Tues., Mar. 23, 6.30 p.m.

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SUMMER SCHOOL OF MINERAL DRESSING

The syllabus of a course in mineral dressing, to be held at a summer school in the Bessemer Laboratory, Royal School of Mines, Prince Consort-road, South Kensington, London, S.W.7, from Tuesday, September 14, to Friday, September 17, has just been published. The course will include lectures on comminution, classification, grinding control, gravity separation, flotation and ancillary processes and is to be illustrated by films, demonstrations and laboratory exercises. The work on each day of the course will commence at 10 a.m. and conclude at 5 p.m. The fee for the course is £10 10*s*. and application forms may be obtained from the Registrar, Imperial College of Science and Technology, Prince Consort-road, London, S.W.7.

Institution of Electrical Engineers

LONDON
"The Kemano Hydro-Electric Development and Associated Kitimat Aluminium-Reduction Works," by F. L. Lawton. Ordinary Meeting. Thurs., Mar. 25, 5.30 p.m.
Demonstration Lecture on "An Experimental and Theoretical Approach to the Teaching of Electro-Magnetism, Using the Rationalised M.K.S. System of Units," by F. A. Meier. Education Discussion Circle. Tues., Mar. 23, 6 p.m.
"Colour Television," by C. J. Hirsch. Radio Section. Mon., Mar. 22, 5.30 p.m.
"Cathode-Spot Performance Phases and Control of Mass Transfer in Vapour-Discharge Devices," by Dr. Ing. H. von Bertele. Supply Section. Wed., Mar. 24, 5.30 p.m.
BRADFORD
Discussion on "High Voltage in Theory and Practice," opened by A. R. Rumfitt. North Midland Centre. Bradford Technical College, Great Horton-road, Bradford. Tues., Mar. 23, 6.30 p.m.
FARNBOROUGH
"The Royal Festival Hall: Electrical Installation," by J. G. Hunter. Southern Centre. Royal Aircraft Establishment Technical College, Farnborough. Wed., Mar. 24, 7.30 p.m.
LIVERPOOL
Faraday Lecture on "Electro-Heat and Prosperity," by O. W. Humphreys. Mersey and North Wales Centre. Philharmonic Hall, Liverpool. Thurs., Mar. 25, 6.45 p.m.
MANCHESTER
Faraday Lecture on "Electro-Heat and Prosperity," by O. W. Humphreys. North-Western Centre. Free Trade Hall, Manchester. Tues., Mar. 23, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"The Kemano Hydro-Electric Development and Associated Kitimat Aluminium-Reduction Works," by F. L. Lawton. North-Eastern Centre. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Mar. 22, 6.15 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Modern Developments in the Design and Manufacture of Welded Pressure Vessels," by M. B. Hamilton and J. McIntyre. Tues., Mar. 23, 6.45 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on (i) "Admiralty Policy is to Operate Small Steam-Turbine Installations at a Steam Temperature of 850 deg. F.: (*a*) Can the Theoretical Thermodynamic Gains from These Conditions be Obtained? (*b*) What is the Optimum Pressure Level in View of the Small Brake Horsepower of the Auxiliary Turbines? (*c*) Is the Use of Plain Carbon Steel at 850 deg. F. Satisfactory? and (ii) What Steam Temperature Limit Should Be Fixed if the Use Alloy Steels is to Be Avoided; or, Alternatively, is Their Use Justified in Spite of the Increased Manufacturing Difficulties Involved, and Are These Manufacturing Difficulties More Apparent Than Real? Steam Group Meeting. Wed., Mar. 24, 6.45 p.m.
Conference on Hydraulic Mechanisms. A series of seven papers. Hydraulics Group. Admission by ticket only. Fri., Mar. 26, 10.30 a.m., 2 p.m and 5.30 p.m.
BIRMINGHAM
"The Motor Cycle as a Utility Machine," by D. W. Munro. Birmingham A.D. Centre. James Watt Memorial Institute, Birmingham. Tues., Mar. 23, 6.45 p.m.
BRIGHTON
"Shell Boilers for the Small Industrial Users," by C. H. G. Hayward. Southern Branch. Technical College, Brighton. Wed., Mar. 24, 7 p.m.
BRISTOL
"Problems in the Design of an Economical Automobile Gearbox," by T. C. F. Stott. Western A.D. Centre. Grand Hotel, Bristol. Thurs., Mar. 25, 6.45 p.m.
GRANTHAM
"Control Valves for Direct Hydraulic Presses and the Application of the System to a 1,000-ton Forging Press," by F. H. Towler and J. M. Towler. East Midlands Branch. Offices of Aveling Barford, Limited, Invicta Works, Grantham, Lincolnshire. Tues., Mar. 23, 7.30 p.m.

Institution of Production Engineers

CARDIFF
"The Relationship Between Factory Administrative Procedure and Financial Control," by W. Crosskey. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Thurs., Mar. 25, 6.45 p.m.
LIVERPOOL
"Induction Hardening," by Dr. R. H. Barfield. Adelphi Hotel, Lime-street, Liverpool. Wed., Mar. 24, 7.30 p.m.
MANCHESTER
"Development of Modern Cutting Tools," by N. T. Heaton. College of Technology, Sackville-street, Manchester. Mon., Mar. 22, 7.15 p.m.
SHREWSBURY
"Industrial X-Rays: Final Interpretation and Acceptance Standards," by E. J. Grinwade. Shrewsbury Technical College, Shrewsbury. Wed., Mar. 24, 7.30 p.m.
STOKE-ON-TRENT
Annual General Meeting at 7 p.m. Also "A Recent Development in Plastics," by E. M. Elliott, at 7.45 p.m. Town Hall, Hanley, Stoke-on-Trent. Mon., Mar. 22.
WORCESTER
"Industrial Incentives," by R. N. Marland. Cadena Café, Worcester. Wed., Mar. 24, 7 p.m.

Institution of the Rubber Industry

MANCHESTER
"Polymer Auxiliaries and Butyl Rubber," by B. J. Habgood. Engineers' Club, Manchester. Mon., Mar. 22, 6.15 p.m.

Institution of Structural Engineers

LONDON
"Gap-Graded Aggregates in Vibrated Concrete," by Dr. T. E. H. Williams. Thurs., Mar. 25, 6 p.m.
BIRMINGHAM
"The Load-Bearing Capacity of Metal Structures," by H. V. Hill. Midland Counties Branch. James Watt Memorial Institute, Birmingham. Fri., Mar. 26, 6 p.m.
MANCHESTER
"The Design and Construction of Reinforced-Concrete Silos and Bunkers," by G. P. Bridges. Lancashire and Cheshire Branch. College of Technology, Sackville-street, Manchester. Thurs., Mar. 25, 6.30 p.m.

Institution of Water Engineers

LONDON
Annual General Meeting. "The Prevention of Stratification in Reservoirs," by P. Cooley and Stephen L. Harris; and "Land Drainage Channel Improvements and Their Possible Effect on Underground Water," by N. Medrington. South-Eastern Section. The Institution of Civil Engineers, Great George-street, S.W.1. Wed., Mar. 24, 2 p.m.

Junior Institution of Engineers

LONDON
"The Design and Application of Pipelines for Drainage Work," by W. D. Haworth. Townsend House, Greycoat-place, S.W.1. Fri., Mar. 26, 7 p.m.
BILSTON
"Some Aspects in the Choice of Electric Motor Control Gear," by J. R. Bell. Midland Section. Offices of Stewarts and Lloyds, Limited, Bilston, Staffordshire. Wed., Mar. 24, 7 p.m.
MANCHESTER
"Developments and Future Possibilities in Electricity Generation," by Sir John Hacking. North-Western Section. Engineers' Club, Manchester. Mon., Mar. 22, 7.30 p.m.

Liverpool Engineering Society

LIVERPOOL
"Industrial Uses of Atomic Energy," by Professor H. W. B. Skinner. Wed., Mar. 24, 6 p.m.

Manchester Association of Engineers

MANCHESTER
Annual General Meeting. "Engineering Aspects of Glass," by Dr. R. E. Bastick and H. Cooper. Engineers' Club, Manchester. Fri., Mar. 26, 6.45 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Cathodic Protection of Cargo Spaces in Oil Tankers," by J. Lamb and E. V. Mathias. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Fri., Mar. 26, 6.15 p.m.

Reinforced Concrete Association

MANCHESTER
"The Design and Construction of Reinforced-Concrete Silos and Bunkers," by G. P. Bridges. College of Technology, Sackville-street, Manchester. Thurs., Mar. 25, 6.30 p.m.

Royal Institution

LONDON
"The Chemical Exploration of the Stratosphere," by Dr. F. A. Paneth. Fri., Mar. 26, 9 p.m.

The Royal Society

LONDON
"Wind Effects on the Motion of the Sea in an Infinite Channel and in a Rectangular Gulf," by G. R. Goldsbrough; and "Eddy Diffusion of Momentum, Water Vapour and Heat Near the Ground," by N. E. Rider. Thurs., Mar. 25, 4.30 p.m.

Royal Society of Arts

LONDON
"The Arts, 1754 to 1954," by Professor Nikolaus Pevsner. Tues., Mar. 23, 2.30 p.m.; "Manufactures, 1754 to 1954," by Sir Ben Lockspeiser. Wed., Mar. 24, 2.30 p.m.; and "Commerce, 1754 to 1954," by Sir Geoffrey Heyworth. Thurs., Mar. 25, 2.30 p.m. Special Bicentenary Lectures.

Royal Statistical Society

LEICESTER
"Statistical Approach to Profit Forecasting," by C. C. Neville. Leicester Industrial Applications Group. Leicester College of Arts and Technology, The Newarke, Leicester. Thurs., Mar. 25, 7 p.m.
SHEFFIELD
"Robust Tests: Which Common Statistical Tests Are Sensitive to Assumptions of Normality, etc., and What Can Be Done About It ?" by Dr. G. E. P. Box. Sheffield Industrial Applications Group. Grand Hotel, Sheffield. Thurs., Mar. 25, 6.30 p.m.

Society of Engineers

LONDON
"An Australian in London," by E. C. Ashcroft. Thurs., Mar. 25, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. (Blackfriars 6178.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Industrial Supervisors, 47 Temple-row, Birmingham.
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Water Engineers, Parliament Mansions, Abbey Orchard-street, London, S.W.1. (ABBey 6740.)
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1. (ABBey 6968.)
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool, 2. (Central 3717.)
Manchester Association of Engineers, 20 Booth-street, Manchester, 2. (Central 2796.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society, Burlington House, Piccadilly, London, W.1. (REGent 3335.)
Royal Society of Arts, John Adam-street, Adelphi, London W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)